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ABSTRACT

This course of study is intended to provide a comprehensive overview of an elementary school science program. In addition to high individual pupil achievement at each grade level, this program is also designed to provide a broad and comprehensive continuum of experiences that lead toward the obtainment of the identified science goals. A strong hands-on component is emphasized in this program. In addition, single topic books are provided to encourage pupils to pursue further inquiries into topics that interest them. The intended result is a "do-read" sequence that enables pupils to have concrete experiences prior to extending their understanding of the content through the use of print materials. A unit format was selected to allow maximum flexibility in building, teaching, and maintaining the elementary school science program. Each unit contributes to the educational outcome identified for the grade level and is the basis for further study at the next level. In this way, a scope and sequence is established and continuity in learning is promoted. Major themes for each grade level form the basis for this continuity. Many of the units incorporate activities from programs such as ESS, SCIIS, and SAVI/SELPH. Specific lesson plans, using the Elements of Instruction, were written by teams of classroom teachers to reduce planning time and teacher anxiety in teaching science. Section 1, "Foundations," includes K-12 learner outcome goals, content, processes and attitudes taught/developed, and a grade 1-6 outcome summary by domain. Section 2, "Science Instructional Program," includes the themes, concept maps, and objectives for each grade level. Section 3, "Environmental Education," includes guidelines, objectives, and resources. Sections 4 and 5 cover supplies and ordering equipment. Section 6, "Science Instruction," includes science fairs, safety, and instructional strategies. Section 7, "Sample Lessons"; includes three lessons for grade 1 and two lessons for grade 4. (KR)

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CONTENT • PROCESS • ATTITUDE

# SCIENCE

EXPLORATION • EXPLANATION

# Course of Study
# Guide to Elementary School Science

U.S. DEPARTMENT OF EDUCATION

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*"Every Student Will Learn"*

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# FOREWORD

This course of study is intended to provide interested educators, parents, and others with a comprehensive overview of the Anoka-Hennepin Independent School District No. 11 elementary school science program. In addition to high individual pupil achievement at each grade level, this program is also designed to provide a broad and comprehensive continuum of experiences that lead toward the obtainment of the science goals that have been identified. It was designed to reflect our professional judgment as to what is best for kids while meeting outcomes necessary for continued science coursework and/or productive and enlightened citizenship.

A strong "hands-on" component is the heart of this program. This approach has been shown, through a number of research studies, to be a characteristic of effective elementary school science programs. In addition, single topic books are provided to encourage pupils to pursue further inquiries into topics that interest them. The intended result is a "do-read" sequence that enables pupils to have concrete experiences prior to extending their understanding of the content through the use of print materials.

A unit format was selected to allow us maximum flexibility in building, teaching, and maintaining the elementary school science program. Each unit contributes to the educational outcomes identified for that grade level and is the basis for further study at the next level. In this way, a scope and sequence is established and continuity in learning is promoted. Major themes for each grade level form the basis for this continuity.

Many of the units incorporate activities from programs such as ESS, SCIIS, and SAVI/SELPH. Specific lesson plans, using the Elements of Instruction, were written by teams of classroom teachers to reduce planning time and teacher anxiety in teaching science. These lessons are considered models or examples, not prescriptions or mandates.

The science instructional program is the result of countless hours of work and the collective thinking of the many talented people in our district: teachers, parents, and other educators. Special recognition should go to the Science and Related Fields Committee for the decisions they made regarding the directions, foundations, and program structure; to the writing teams who brought the ideas to reality for classroom teachers and pupils; to those involved in providing the teaching staff with in-service programs; to the people who assembled the kits; and to the administration and School Board for their acceptance of our recommendations. The staff, pupils, and citizens of Anoka-Hennepin Independent School District No. 11 thank you.

Science and Related Fields Committee (1984-87)

Grade 1 - Laurie Good, Eisenhower
Grade 2 - Marceille Myers, Hoover
Grade 3 - Mary Jo Walz, L. O. Jacob
Grade 4 - Howard Scherzer, Jefferson
Grade 5 - Dave Peterson, Champlin
Grade 6 - Miriam Seim, Mississippi
Grade 6 - Bonnie Johnson, Oxbow Creek
Secondary Science - Sharron Krize, Northdale Junior High
Media - Shirley Christenson, LC/DC
Parent - Mary Youngquist, Lincoln area
Parent - Mary Weisenel, Jefferson area
Parent - Rosalie Krusemark, Crooked Lake area
Principal and Chair - Ronald Rude, Lincoln
Principal - Jerry Johnson, Mississippi
Principal - Ken Kunshier, Jefferson
Consultant - Rod Vacek, ESC

Curriculum Writing Teams (1987)

Grade 1

Laurie Good, Eisenhower
Bonnie Hagelberger, Monroe
Sue Antel, Sorteberg
Paul Peterson, Champlin

Grade 2

Marceille Myers, Hoover
Helen Kernik, Eisenhower

Grade 3

Vicki Larsen, Eisenhower
Mark Reier, McKinley

Grade 4

Joan Eistad, Hamilton
Tom Geisenhoff, Monroe
John Soholt, Jefferson

Grade 5

Gayle Geisenhoff, Sand Creek
Rick Gillson, Adams
Pat Flynn, Monroe

Grade 6

Judy Curtiss, Sand Creek
Miriam Seim, Mississippi

## PREFACE TO THE FOUNDATIONS OF THE SCIENCE PROGRAM

Science as a discipline to be studied in elementary schools consists of three dimensions or domains: a body of knowledge (content), a way of looking at and studying natural phenomena (process), and a spirit of inquiry and inquisitiveness that characterizes the men and women who practice sciencing (attitude). Each dimension is equally important for a person to be considered scientifically literate and our program incorporates these domains.

Because the content of science is expanding at such an enormous rate, it is possible to cover only a fraction of it in a K-12 program. Therefore, activities were selected to provide opportunities for pupils to become familiar with many aspect of the natural world. These activities enable them to experience science in a way that is developmentally appropriate and in line with our beliefs about science and the stated learner outcome goals.

## BELIEFS ABOUT SCIENCE

1. **Science is a basic discipline to be learned.**
   a. Science should be given adequate instructional time.
   b. Science instruction should be supported by district and building administrators.

2. **All children can learn science.**
   a. Science instruction should be flexible to meet the needs of all learners.

3. **All children should be given the opportunity to learn science.**

4. **All teachers can teach science.**

5. **Science is an integral part of life and therefore should address societal needs.**
   a. Science should address real world issues.
   b. Science lessons should include career applications whenever possible.
   c. Science should make use of community resources.

6. **Science should be taught using "hands-on" methods that require concrete objects.**

7. **Science includes components of content, process, and attitudes.**
   a. Science instruction should teach concepts, principles, and laws from earth, life, physical and environmental science.
   b. Basic process skills of observing, inferring, measuring, classifying, using numbers, using space-time relationships, communicating and predicting should be taught.
   c. Integrated processes that promote higher level of thinking such as defining operationally, formulating hypotheses, interpreting data, controlling variables, and experimenting should be taught at appropriate levels.
   d. Positive attitudes towards science and science investigation should be taught, including curiousity, inventiveness, critical thinking, persistence, problem-solving, and decision-making.

8. **Science knowledge is constantly changing and increasing in quantity.**
   a. Decisions regarding the content to be taught should be based on criteria that centers on the learner interest and aptitude, and desired district outcomes.

9. **Science should be taught in an atmosphere open to all ideas.**

10. **Science is an important part of other disciplines and science learnings are not limited to this discipline.**

11. **Learning science should be made attainable and appealing.**

12. **Science classes should make use of research findings on learning and child development.**
    a. Cooperative learning groups should be used often.
    b. Learning styles should be considered when designing lessons.
    c. Lessons should be designed to be most productive.

**ANOKA-HENNEPIN ISD-11**

**SCIENCE PROGRAM OUTCOMES**

**K-12**

Domain I. KNOWLEDGE

A. Facts, vocabulary, and equipment

The student will:

1. **Know and/or apply terminology of earth, life, and physical science**
2. **Know and/or apply facts and content basic to an understanding of earth, life, and physical science**
3. **Recognize science equipment and identify its function**

B. Scientific concepts

1. The student will **know fundamental science concepts and related theories, laws, and assumptions:**

a. cause-effect
b. change
c. cycle
d. energy-matter
e. entropy
f. equilibrium
g. evolution
h. field
i. force
j. fundamental entities
k. gradient
l. interaction
m. invariance
n. model
o. order
p. organism
q. perception
r. probability
s. population
t. quantification
u. replication
v. resonance
w. scale
x. significance
y. symmetry
z. system
aa. theory
bb. time-space
cc. validation

Domain II. COMPETENCE

A. Basic inquiry skills

The student will:

1. **Observe and describe properties of objects**
2. **Use and apply classification skills**
3. **Use and apply common scientific and mathematical symbols**
4. **Use and make reasonable predictions and/or inferences**
5. **Communicate ideas, findings, procedures, et cetera, clearly and accurately in written and/or oral form**

B. Integrated inquiry skills

The student will:

1. **Know and apply skills related to forming a hypothesis**
2. **Know and apply skills related to the identification and controlling of variables**
3. **Know and apply skills in designing and conducting an experiment**
4. **Know and apply skills in collecting and analyzing data**
5. **Know and apply skills in constructing and evaluating conclusions**
6. **Know and apply skills related to communicating abstract ideas through model building, including their use and limitations**
7. **Identify and use analogies to communicate abstract relationships**
8. **Identify and use systems of reference for orientation in space and time**

C. Laboratory skills and techniques

1. The student will **know and be able to perform a variety of laboratory skills and techniques such as:**
   a. Preparing microscope slides and other materials for study
   b. Using scientific apparatus properly
   c. Transferring materials from one container to another when conducting investigations
   d. Caring for live organisms

Domain III. ORIENTATIONS

A. Attitudes toward science and the learning process

The student will:

1. **Develop interest in taking additional science courses**
2. **Demonstrate interest in science in nonformal settings**
3. **Demonstrate interest in the aesthetic value of nature**
4. **Identify applications of science content to all areas of life**
5. **Contribute to investigations and class discussions**
6. **Develop curiosity, inventiveness, critical thinking, and persistence when confronted with a problem or phenomena**
7. **Value critical thinking and evaluate evidence**
8. **Recognize different approaches to problem solving and data interpretations**

B. Using scientific processes in personal decision making

The student will:

1. **Use scientific processes in the area of consumerism**
2. **Use scientific processes to distinguish between folklore and the unknown**
3. **Consider scientific evidence in making personal decisions**

C. Attitudes about the social implication of science

The student will:

1. **Know ways science and technology have changed their lives**
2. **Recognize moral dimensions of science discoveries and applications in society**
3. **Develop a sense of custodianship for material things, natural resources, and the environment**

4. Use information and values in decision-making, including evaluating the consequences for others in the community
5. Recognize that science will not provide "magic" solutions or easy answers - instead, hard work and the processes of science are required to "resolve" rather than "solve" many problems

D. Attitudes regarding contributions of scientists

The student will:

1. Know about important men and women and their contributions to science
2. Recognize that scientists and technicians are people with personal and human characteristics
3. Recognize that both sexes, minorities, and handicapped people are valued in science-related careers, have contributed to science and society, and continue to do so

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## CONTENT, PROCESSES AND ATTITUDES TAUGHT/DEVELOPED

Domain I: CONTENT ASPECTS OF SCIENCE

**A. Facts and Science Vocabulary**

| Grade 1 | Grade 2 | Grade 3 |
|---|---|---|
| habitat | life cycle | brine shrimp |
| food chain | metamorphosis | daphnia |
| male/female | germination | damselfly larvae |
| birth | seed parts | aphid |
| death | biotic potential | dispersal |
| plant/animal | hydroponics | plant eater |
| living/nonliving | plant growth | animal eater |
| property | & development | predator |
| solids | animal growth | prey |
| liquids | & development | food web |
| material | interaction-at-a-distance | mixture |
| object | evidence of interaction | solution |
| | gear systems | concentration |
| | dissolving | schlieren |
| | magnets | filtration |
| | copper chloride interactions | density |
| | temperature | |
| | wind | |

| Grade 4 | Grade 5 | Grade 5 Cont. |
|---|---|---|
| ameba | tree studies | resistance |
| paramecium | structures | brightness |
| euglena | buds | astronomy |
| cell | classification | solar system |
| crayfish | water conduction | relative position & motion |
| molting | growth | moon phases |
| territorial behavior | branches | constellations |
| habitat | twigs | comets |
| scale | shape | asteroids |
| magnification | bark | meteroids |
| rocks | circuits | space travel |
| minerals | parallel | chemical reactions |
| crystal | series | solution |
| property | short | indicator |
| magnetism | batteries "special places" | cohesion |
| streak plate | bulbs "special places" | adhesion |
| pendulum | conductors | surface tension |
| | nonconductors | capillary action |

Grade 6

classification:
- mammal vs. fish
- whale species

ocean food chains/webs
whale characteristics
specialized terms:
- fluke
- dorsal fin
- breach
- lobtail

fingerprint types
ear structures
population
habitat
organism size/food intake relationships
animal behavior
hypothermia
body heat regulation
recycle
compost
role of ocean
water pressure
ocean characteristics
temperature/heat
condensation/evaporation
sound vibrations and mediums
frequency
volume
displacement
floating
buoyancy
levers
machines
friction
gears
ratios
transmission of motion

B. **Scientific Concepts**
(by grade level)

Grade 1

organism
order
symmetry

Grade 2

cycle
change
interaction
system

Grade 3

population
variable
subsystem
quantification

Grade 4

fundamental entity (cell)
scale
field
interaction
order
perception

Grade 5

interaction
variable
system
subsystem
quantification
scale
perception

Grade 6

cause-effect
change
cycle
force
model
order
scale
theory
space/time
replication

Domain II: SKILLS

**A. Basic Inquiry Skills**
(Grades 1-6)

observe
classify
order
communicate
predict
quantify
infer

**B. Integrated Skills**

| Grade 3 | Grade 4 | Grade 5 and 6 |
|---|---|---|
| identify variables | identify variables | identify variables |
| control variables | control variables | control variables |
| | conduct experiments | conduct experiments |
| | analyze data | analyze data |
| | | model building |
| | | use of analogies |
| | | use space/time relationships |

C. Lab Skills and Techniques

| Grade 1 | Grade 2 | Grade 3 |
|---|---|---|
| prepare habitat | prepare habitat | prepare habitats |
| use magnifiers | use magnifiers | use magnifiers |
| | use magnets | care for plants |
| | care for plants | care for animals |
| | | transfer liquids |

| Grade 4 | Grade 5 | Grade 6 |
|---|---|---|
| use microscopes | use charts | use computers |
| prepare microscope slides | transfer material | use compasses |
| care for animals | use volume measuring instruments | use models |
| prepare habitats | care for plants (trees) | care for an animal |

Domain III: ATTITUDES

All the attitudes listed in the Learner Outcome Goals: Science, are introduced, developed, and promoted at appropriate times within the instructional program designed for each grade level. The hands-on activities especially promote curiosity, inventiveness, critical thinking, and persistence in problem-solving and investigating phenomena at all levels. Particularly noteworthy is the grade six component that stresses very clearly and specifically the attitudes listed in Sections III B, C, D.

# LEARNER OUTCOME GOALS: SCIENCE

## Domain I: Content

Key:
I - Introduce
T - Taught
A - Apply
E - Experience
P - Potential Experience
• - Optional Lessons

| Unit | 1A 1. Know and/or apply terminology of earth, life, and physical science | 1A 2. Recognize simple science equipment and identify its function | 1A 3. Know and/or apply facts and basic concepts of earth, life, and physical science | 1B 1. Concepts: Cause-effect | 1B 2. Change | 1B 3. Cycle | 1B 4. Energy-matter | 1B 5. Entropy | 1B 6. Equilibrium | 1B 7. Evolution | 1B 8. Field | 1B 9. Force | 1B 10. Fundamental entities | 1B 11. Gradient | 1B 12. Interaction | 1B 13. Invariance | 1B 14. Model | 1B 15. Order | 1B 16. Organism | 1B 17. Perception | 1B 18. Probability | 1B 19. Population | 1B 20. Quantification | 1B 21. Replication | 1B 22. Resonance? | 1B 23. Scale | 1B 24. Significance | 1B 25. Symmetry | 1B 26. System | 1B 27. Theory | 1B 28. Time-space | 1B 29. Validation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade 1 | T | T | T | | I | | | | | | | | | E | E | | | T | T | I | | | | | | | T | | | | |
| Grade 2 | T | T | T | I | T | T | | | | | | | | | T | | | A | A | A | | | | | | | A | T | | | |
| Grade 3 | T | T | T | T | A | A | | | | | | | | E | A | | | A | A | A | | T | E | I | | | A | A | | | |
| Grade 4: Scientific Reasoning | T | T | T | A | A | A | | | | | | I | | | A | E | | A | | A | | | E | T | | | A | A | | | E |
| Small Things | T | T | T | A | A | A | | | | | | | I | | A | | | A | A | A | | A | E | | | T | | A | A | | | |
| Rocks and Minerals | T | | T | A | A | A | | | | | | | | I | A | | | A | | A | | | | | | | | A | A | | | E |
| Crayfish | T | | T | A | A | A | | | | | | | | | A | | | A | A | / | | A | E | A | | | | A | A | | | E• |
| Grade 5: Astronomy and Space | T | T | T | A | A | A | | | | | | | E | E | A | E | I | A | | T | | | E | A | | A | | A | A | | I | |
| Household Science | T | T | T | A | A | | I | | E | | | | E | | A | | | A | | A | | | E | A | | | | | A | | | E |
| Batteries and Bulbs | T | T | T | A | A | | E | | | | I | E | | E | A | E | E | A | | A | | | E | A | | | | | A | | | E |
| Patterns in Trees and Twigs | T | | T | A | A | A | | | | | | | | | A | | E | A | A | A | | A | E | | | | | A | A | | | |
| Grade 6: Voyage of the Mimi | T | T | T | A | A | A | | | | I | E | E | E | E | A | E | E | A | A | A | | A | E | A | E | A | | A | A | I | E | E |
| Simple Machines | T | T | T | A | A | A | E | | E | | | E | | | A | E | T | A | | A | | | E | A | | A | | A | A | | | |
| Science World | T | | T | P | P | P | P | | P | P | | P | P | | P | P | P | P | P | P | P | P | P | | | P | | P | P | P | P | P |

# LEARNER OUTCOME GOALS: SCIENCE

## Domain II: Skills

Key:
I - Introduce
T - Taught
A - Apply
E - Experience
P - Potential Experience
* - Optional Lessons

| Unit | IIA 1 Observe and describe properties of objects | IIA 2 Use and apply classification skills | IIA 3 Use and apply common scientific and mathematical models | IIA 4 Use and make reasonable predictions and/or statements | IIA 5 Communicate ideas, findings, procedures, or criteria clearly and accurately in written and/or oral form | IIB 1 Know and apply skills related to forming a hypothesis | IIB 2 Know and apply skills related to the identification and controlling of variables | IIB 3 Know and apply skills in designing and conducting an experiment | IIB 4 Know and apply skills in collecting and analyzing data | IIB 5 Know and apply skills in constructing and evaluating conclusions | IIB 6 Know and apply skills related to model building | IIB 7 Identify and use analogies to communicate abstract relationships | IIB 8 Identify and use systems of reference for orientation in space and time | IIC 1 Know how to prepare microscope slides and other materials for study | IIC 2 Use scientific apparatus properly | IIC 3 Know and use laboratory skills, such as transferring materials from one container to another, when conducting investigations | IIC 4 Know and use skills in caring for live organisms | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade 1 | T | T | T | E | T | | | E | E | | | | | | T | | T | | | |
| Grade 2 | A | A | | T | A | | | | E | E | | | | | E | | A | | | |
| Grade 3 | A | A | | A | A | | T | T | T | T | | | | | E | T | A | | | |
| Grade 4: Scientific Reasoning | A | A | A | A | A | T | A | A | T | T | | | | | E | E | | | | |
| Small Things | A | A | | A | A | | A* | | | | | | | T | T | A | A | | | |
| Rocks and Minerals | A | A | A | A | A | | | | A | A | | | | | | A | | | | |
| Crayfish | A | A | | A | A | | A | A* | A | A | | | I | | | | A | | | |
| Grade 5: Astronomy and Space | A | A | A | A | A | | | | A | A | T | E | T | | | | | | | |
| Household Science | A | A | | A | A | E | A | A | A | A | | E | | | A | A | | | | |
| Batteries and Bulbs | A | A | T | T | A | | A | A | A | A | E | E | | | A | | | | | |
| Patterns in Trees and Twigs | A | A | | A | A | | | | A | A | E | E | | A | A | | A | | | |
| Grade 6: Voyage of the Mimi | A | A | A | A | A | T | A | A | A | A | E | E | A | | T | | A | | | |
| Simple Machines | A | A | A | A | A | | | A* | A | A | T | A | | | A | | | | | |
| Science World | | | | P | | | P | | | P | P | P | P | | | | | | | |

# LEARNER OUTCOME GOALS: SCIENCE

## Domain III: Attitudes

Key:
I - Introduce
T - Taught
A - Apply
E - Experience
P - Potential Experience
* - Optional Lessons

| Unit | IIIA 1 Develop interest in taking additional science courses | IIIA 2 Demonstrate interest in science in nonformal settings | IIIA 3 Demonstrate interest in the aesthetic value of nature | IIIA 4 Identify applications of science content to all areas of life | IIIA 5 Contribute to investigations and class discussions | IIIA 6 Develop curiosity, inventiveness, critical thinking, and persistence how confronted with a problem or phenomena | IIIA 7 Value critical thinking and evaluate evidence | IIIA 8 Recognize different approaches to problem solving and data interpretations | IIIB 1 Use scientific processes in the area of measurement | IIIB 2 Use scientific principles to distinguish between superstitions and the unknown | IIIB 3 Consider scientific evidence in making personal decisions | IIIC 1 Know ways science and technology have helped shape lives by knowing the related skills available to them | IIIC 2 Recognize moral dimensions of science discoveries and applications in society | IIIC 3 Possess a sense of curiosity/love for natural things, natural resources, and the environment | IIIC 4 Use information and others to make decisions and evaluate the consequences for others in the community | IIIC 5 Recognize that science will not provide magic solutions or easy answers, realize the role of hard work and the processes of science are required to resolve rather than solve many problems | IIID 1 Know about important men and women and their contributions to science | IIID 2 Recognize that scientists and technicians are people with personal and human characteristics | IIID 3 Recognize that both men, minorities, and handicapped people have equal access to science related careers, have contributed to science and society, and continue to do so | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade 1 | P | P | P | P | T | E | | | | | | | | P | P | | | | | |
| Grade 2 | P | P | P | P | T | E | | | | | | | | P | P | | | | | |
| Grade 3 | P | P | P | P | T | E | I | | | | | | | P | P | | | | | |
| Grade 4: Scientific Reasoning | P | P | P | P | T | E | A | P | | | | | | | | | | | | |
| Small Things | P | P | P | P | T | E | | P | | | | | | P | P | | | | | |
| Rocks and Minerals | P | P | P | P | T | E | A | P | | | | | | P | | | | | | |
| Crayfish | P | P | P | P | T | E | A | P | | | | | | P | P | | | | | |
| Grade 5: Astronomy and Space | I | P | P | P | T | E | A | P | P | P | | E | | P | | P | P | T | | |
| Household Science | I | P | P | P | T | E | A | P | P | P | | | | | | | | | | |
| Batteries and Bulbs | I | P | P | P | T | E | A | P | P | | | | | | | | | | | |
| Patterns in Trees and Twigs | P | P | P | P | T | E | | | P | | | | | P | P | | | | | |
| Grade 6: Voyage of the Mimi | I | P | P | P | T | E | A | E | P | P | | E | P | P | P | E | T | T | T | |
| Simple Machines | P | P | P | P | T | E | | E | | | | E | | | | | | | | |
| Science World | P | P | P | P | T | E | P | P | P | P | | P | P | P | P | P | P | P | P | |

## PREFACE TO THE INSTRUCTIONAL PROGRAM

Grades Kindergarten-3

The primary grades program (K-3) follows the basic structure developed by the Lawrence Hall of Science, Berkeley, California, in the original SCIIS (Science Curriculum Improvement Study) program. Each unit contributes to a gradual, but increasingly expanded, view of the world of science. The concepts taught are powerful working concepts that will serve the pupils well in understanding the world around them. By the end of grade 3, pupils will have been introduced to formal science (experimenting) through the introduction of the concept of a variable.

A writing team for each grade level 1-3 used their teaching experiences and those of their colleagues to improve upon an already highly effective and quality program. Some activities were dropped, others added, and still others were modified. These activities were written in a teachable format and placed within a learner sensitive structure. The end result is a cohesive year-long program. We think the improvements made will serve our pupils well.

Grades 4-6

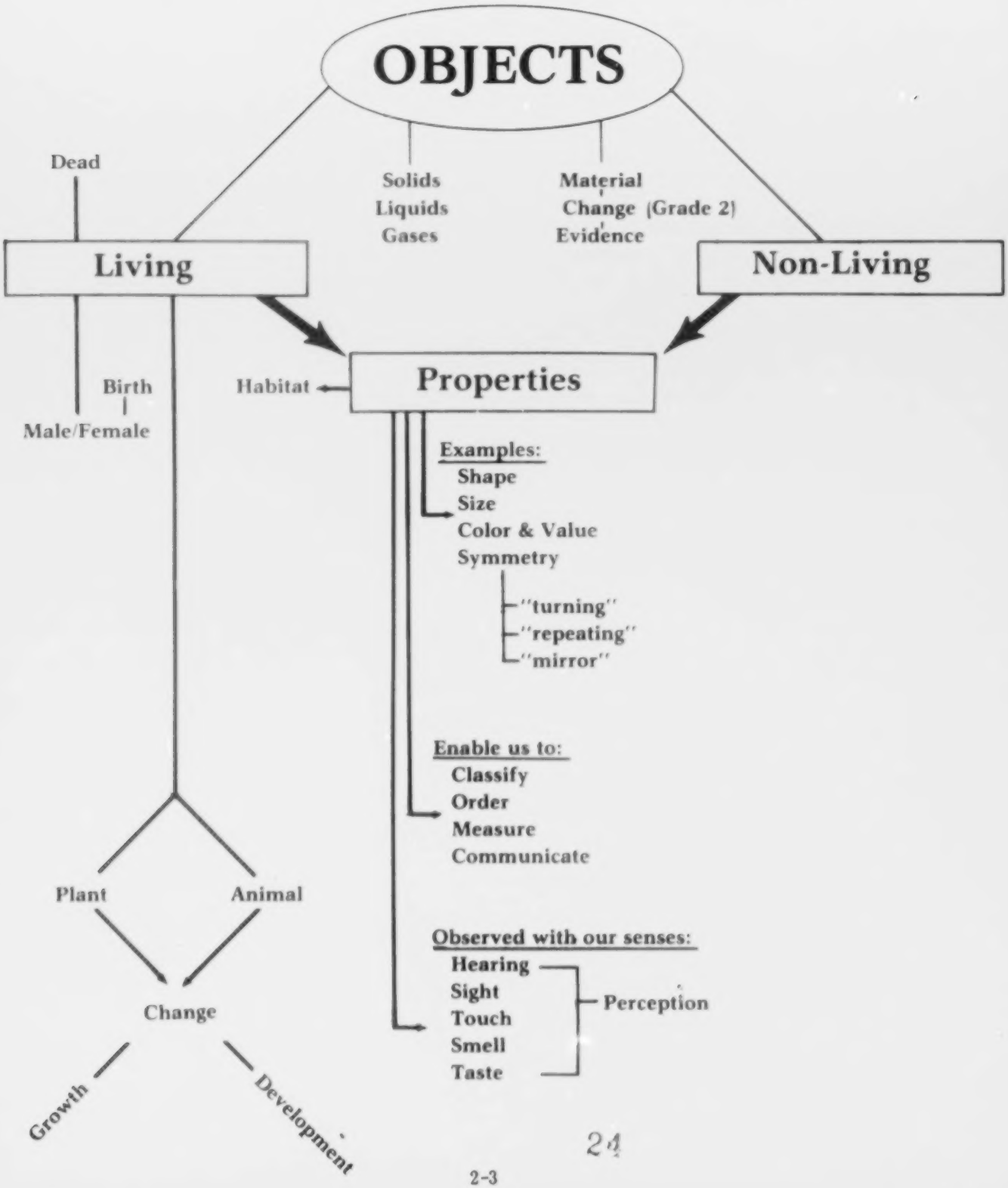
Beginning at grade 4, the program takes on a unit approach. This allows us to respond in a positive way to the concerns expressed by our professional teaching staff. First of all, it allows us to plan for experiences within a wider range of phenomena. This lessens the tendency for redundancy. Second, by having four units per grade level, each teacher can have access to the complete kit of materials for an entire quarter. Last, by limiting the number of units, the materials needed can be provided and maintained in necessary quantities.

The grade 6 program is unique in that it consists of three units of study of varying length. The Voyage of the Mimi unit is intended to be a semester in duration. It includes mini units that enable pupils to participate in additional hands-on experiences. The Simple Machines (LEGO) unit is designed for a normal quarter of study. Science World is a bi-monthly magazine that is received throughout the year and is used at appropriate times and in appropriate ways as determined by the classroom teacher.

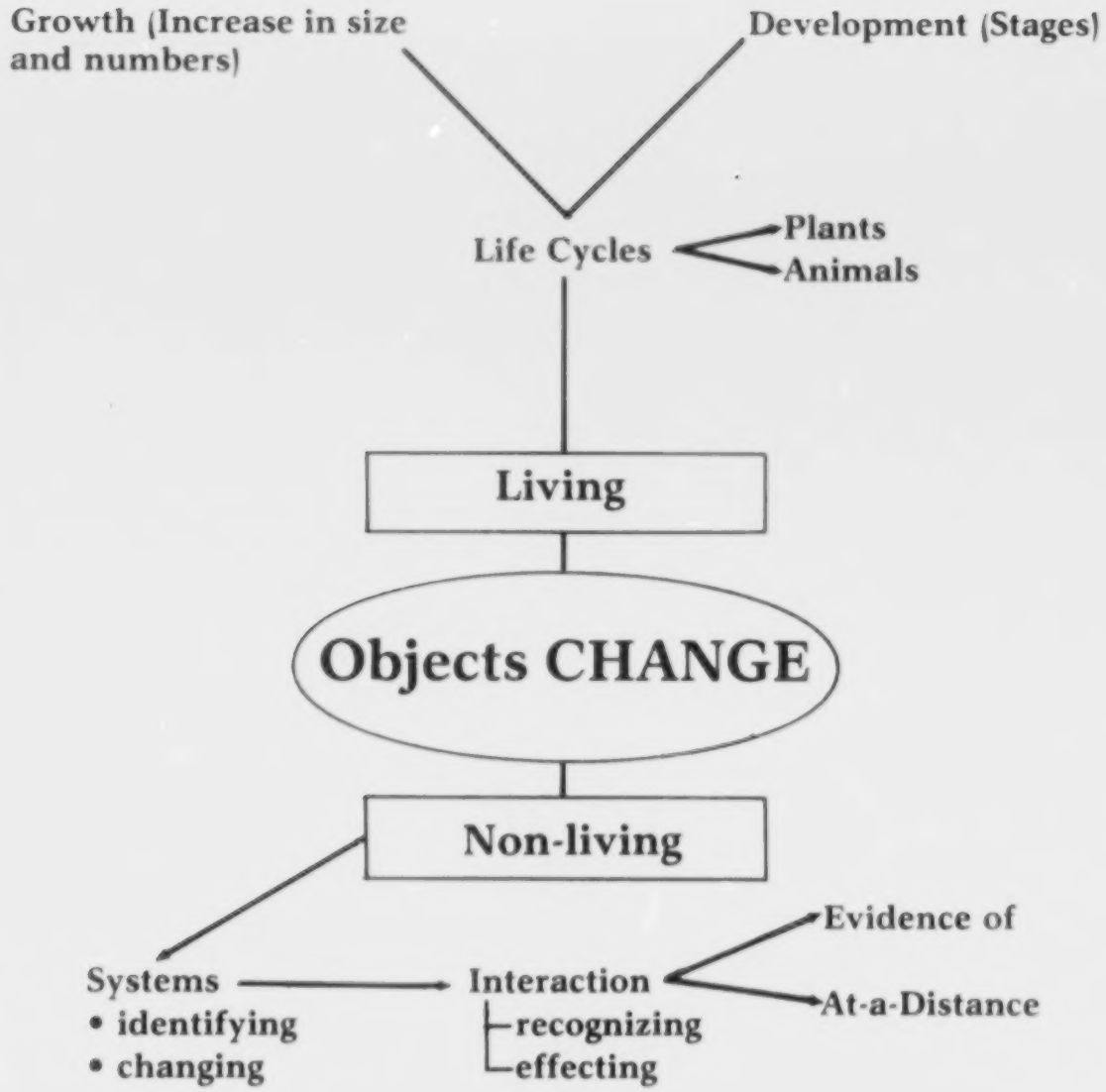
# D-11 Elementary School Science Program Summary

| | |
|---|---|
| **Grade Six:** | • Science is a human endeavor<br>• Scientists are people<br>• Technology is invented to serve a need |
| **Grade Five:** | • Inquiries can be made into areas beyond our senses<br>• Patterns found<br>• Explanations presented based on evidence |
| **Grade Four:** | • Inquiries can be made about the world — observing, experimenting, communicating, using special tools and equipment |
| **Grade Three:** | • System Change<br>• Subsystems can be found<br>• Variables can be identified and controlled |
| **Grade Two:** | • Objects Change, Interact<br>• Objects can form systems |
| **Grade One:** | • Objects have properties that can be communicated |
| **Kindergarten:** | • Readiness — Communicating |

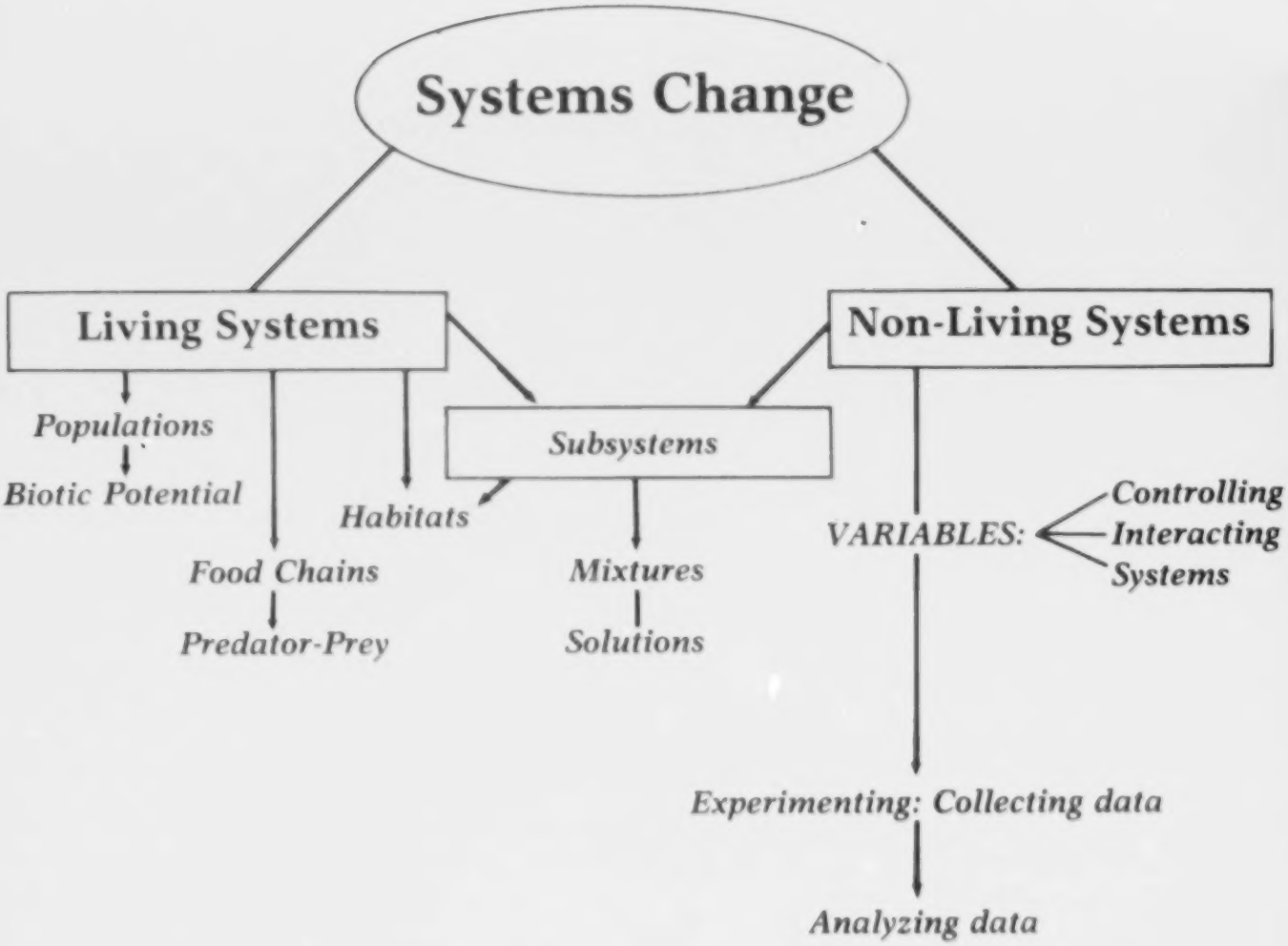
# Grade One: *Becoming Familiar With Things In The World*



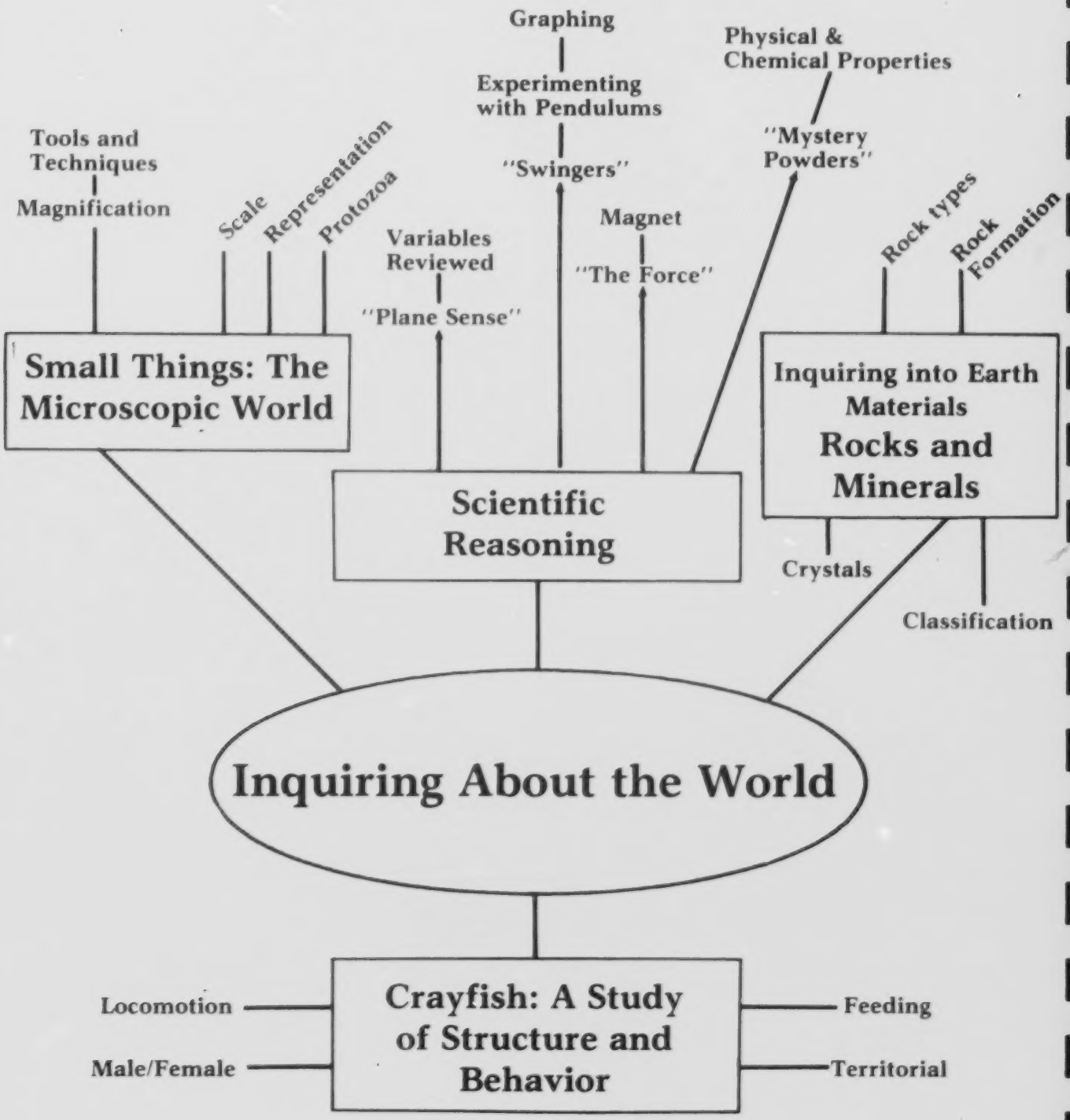
# Grade Two: *Becoming Familiar With Some Changes in Things*



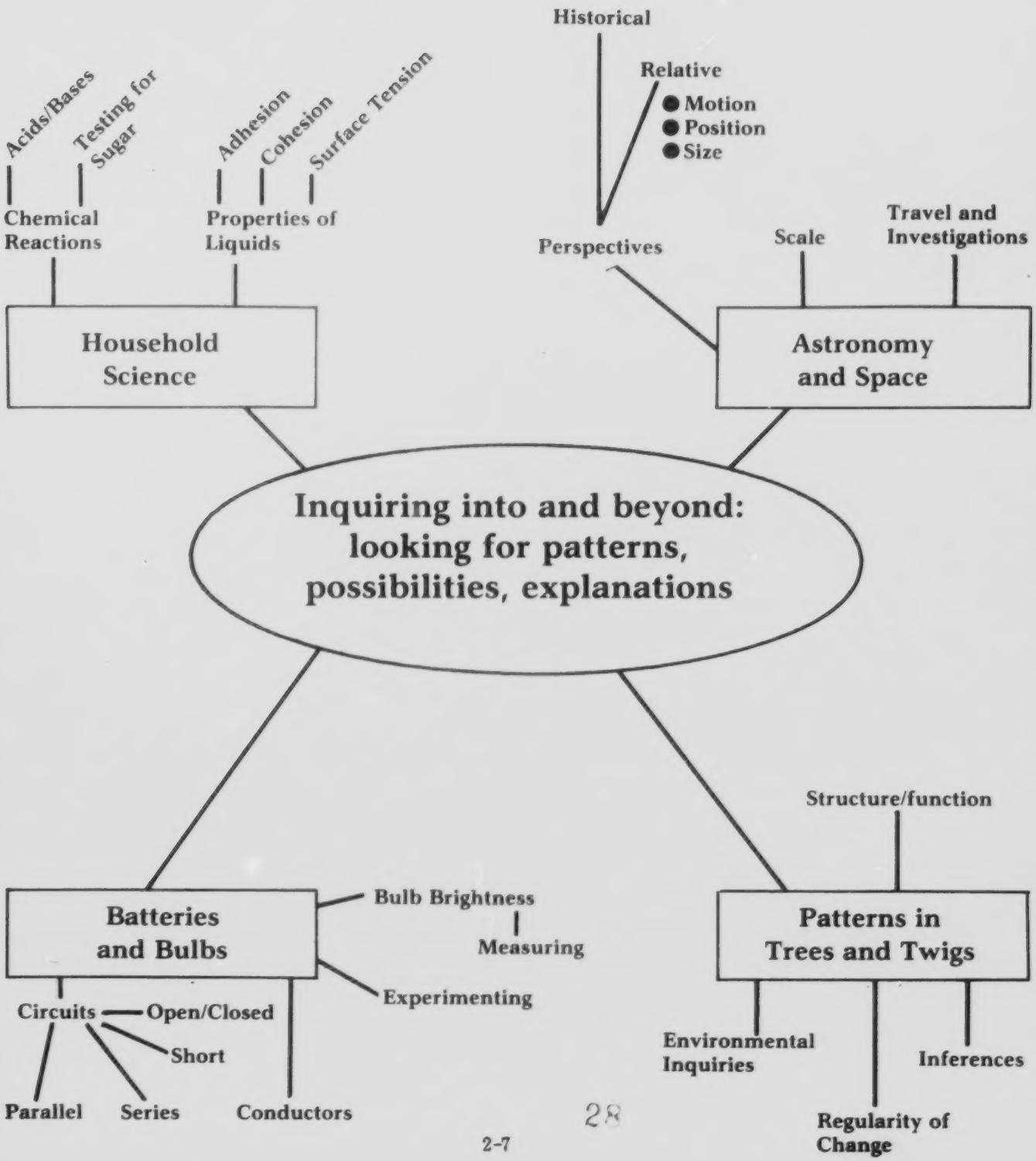
# Grade Three: *Becoming Familiar With Our Ability to Cause Changes and Learn From Them*



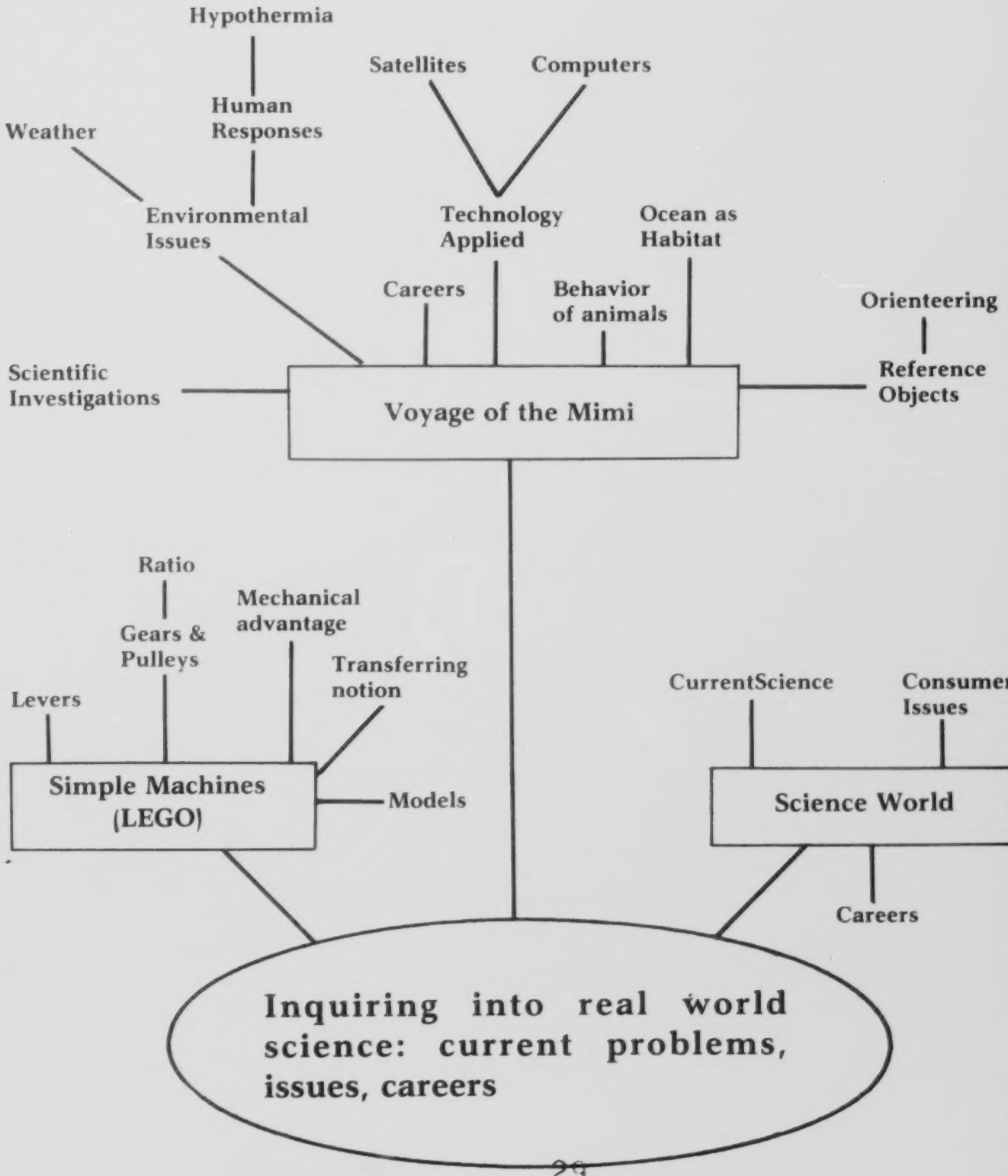
# Grade Four: *Purposeful and Planned Inquiries*



# Grade Five: *Further Inquiries — New Frontiers*



# Grade Six: *Science In My World*



## KINDERGARTEN

Pupils learn the following as part of their kindergarten science instructional program.

UNITS OF LEARNING:

1. **Color**
   To identify and name various colors.
   To compare and describe objects according to color.

2. **Shape**
   To identify and name shapes.
   To compare and describe objects according to shape.
   To group objects according to shape.
   To develop the ability to trace and draw shapes.

3. **Texture**
   To becom more aware of the sense of touch.
   To compare and describe textures.
   To develop vocabulary for describing textures.

4. **Odor**
   To become more aware of the sense of smell.
   To compare and describe odors.
   To develop vocabulary for describing odors.

5. **Sound**
   To become more aware of sounds.
   To compare and describe sounds.
   To develop vocabulary for describing sounds.

6. **Size**
   To compare and describe objects by size.
   To introduce the use of magnifiers.
   To increase the child's vocabulary for describing size.

7. **Quantity**
   To count and compare quantifies of objects.
   To make simple measurements.
   To use language to compare collections of objects by number.

8. **Position**
   To describe the position of an object in relation to other objects.
   To use position clues in order to decide where to place an object.

9. **Organisms**
   To observe and describe plants and animals.
   To describe a series of events in sequence.

## GRADE ONE

The grade one science program is intended to introduce pupils to more details of the world around them by having them closely observe objects and communicate descriptions of these objects. Nonliving and living objects are examined and concepts basic to further studies in science are introduced.

UNITS OF LEARNING:

1. **The Senses**
   This unit introduces pupils to the senses that enable them to learn about the world: sight, smell, hearing, touch, and taste. Pupils learn to describe objects as completely as possible using the information available to them through these senses.

2. **Properties**
   Pupils use the word object when referring to a piece to a matter. Through experience, they develop discrimination skills that enable them to identify and describe various objects by their properties; size, shape, color, and symmetry. They learn to sort, order, and classify which enables them to see relationships between objects and communicate these relationships to others.

3. **Material Objects**
   Pupils identify some of the materials of which objects are made and categorize objects according to these materials. They distinguish between objects composed of one material and objects made of many materials.

4. **Aquariums**
   Pupils learn to recognize and describe birth, death, feeding, growing, and other events in the aquarium and use the word organism for plants and animals. They use the term habitat to refer to a place where an organism lives and describe habitats found in the school area. They make hypotheses about the reasons for aquariums turning green and devise and carry out experiments to test these hypotheses. Pupils use the term food chain to describe the feeding relationship among organisms when they determine what various organisms eat and what each is eaten by. They observe and describe the gradual collection of "black stuff" - detritus - in an aquarium and propose and test hypotheses about the source of detritus. They use the term decay to describe the breakdown of organic matter and to describe the effect of detritus on plant growth.

5. **Seeds and Plants**
   Pupils describe seeds and grow seeds from plants. They observe and record properties of the seeds and the resulting plants. They state some requirements for seed germination and plant growth.

## GRADE TWO

The theme of the science program at this level is change. Objects change and interact. Pupils observe and study changes in living and nonliving systems.

UNITS OF LEARNING:

1. **Review of Material Objects**
   Pupils review the concepts of object, material, and property by describing the properties of objects. They group and serial order objects according to a property in order to better see similarities and differences.

2. **Interaction**
   Pupils isolate and manipulate groups of objects and identify interacting objects in experiments. They describe changes that occur during an experiment and identify these changes as evidence of interaction .

3. **Systems**
   Pupils identify systems of interacting objects and identify systems that show evidence of interaction. They keep track of a system when its parts are manipulated in various ways and use the word interaction when referring to objects that do something to each other. Pupils use the word system to refer to a group of related objects and experiment with gear systems. They qualitatively predict relative turning rates of interacting gears or pulleys.

4. **Evidence of Interaction**
   Pupils investigate interacting systems and interpret dissolving, color change, crystal formation, heating, and bubbling as evidence of interaction. They experiment and write a report. They keep track of an interacting system even though it undergoes a chemical change. They then investigate evidence of interaction in weather related systems of temperature and wind.

5. **Interaction-At-a-Distance**
   Pupils investigate systems of objects that interact at a distance including static elecricity, sound, and magnets. They identify objects that do not interact at a distance with magnets.

6. **Living Things**
   Pupils identify organisms, describe habitats, and illustrate a food chain. They list the characteristics of living, dead, and nonliving objects. They sort organisms into plant and animal groups.

7. **Life Cycles - Plants**
   Pupils study the development and growth of plants in hydroponic systems. They study the structures of a plant: roots, stems, leaves, and flowers. They arrange illustrations of plants in various stages of development in order from seed to adult. They also find, plant, and successfully grow seeds they bring into the classroom.

8. **Life Cycles - Animals**
   Pupils identify eggs and differentiate them from seeds. They study and record the development of various animals (insects) from eggs into larva. They identify the life cycle stages of frogs, crickets, fruit flies, moths, butterflies, and mealworms, and arrange in sequential order pictures of stages in the life cycles of a common animal. They use and apply the term metamorphosis correctly and understand that it refers to the developmental sequence of certain animals.

## GRADE THREE

The focus of the year's study is that systems can change and smaller systems (subsystems) can be found within a system. The powerful and basic concept in science of variables is introduced.

UNITS OF LEARNING:

1. **Systems and Interaction**
   Pupils observe properties of objects and investigate the interaction of objects. They look for evidence in interacting systems to help them understand and interpret the changes that occur.

2. **Subsystems**
   Pupils use the word **subsystem** when referring to a system that is part of another system and identify subsystems in a mixture of solids. They explore new subsystems while investigating "whirlybirds."

3. **Solutions**
   Pupils classify liquid mixture as **solutions** or **nonsolutions.** They investigate solutions created with food coloring in warm and cold water. Investigations into processes for separating solution mixtures include filtration, evaporation, and paper chromatography. They investigate concentration as a factor in solutions and interpret schlieren as evidence of dissolving. In addition, they investigate the concept of density through layering in liquid mixtures.

4. **Histograms**
   Pupils learn to construct, use, and interpret **histograms.** They collect data from a variety of activities and display it in graph form (histogram).

5. **Variables**
   Pupils identify and describe factors that make a difference in the system. They investigate various interacting systems and use the term **variable** when referring to these factors. They experiment and control the variables in a variety of situations.

6. **Organisms**
   Pupils investigate the characteristics of an **organism** (brine shrimp) and its habitat. They observe and describe its response to an environmental factor. They also observe the growth and development of brine shrimp and devise simple experiments to determine the variables that affect growth and behavior in brine shrimp.

7. **Populations**
   Pupils learn to use the term **population** to refer to a group of organisms of one kind living and reproducing in a particular area. They identify different populations that share the same environment and observe the growth and development of an organism. They identify variables that might effect particular populations and the response of the populations to these variables. The concept of biotic potential is developed and pupils describe the effect of birth and death on population size.

8. **Plant Eaters**
Pupils study animals (crickets and aphids) that eat plants and observe the effect on both as the population of one changes. Food webs are diagrammed to illustrate feeding relationships among plant eaters.

9. **Predator-Prey**
Pupils observe and describe the interaction among predators and prey. They use the term **predator** to describe an animal that eats another animal and the term **prey** to describe the animal being eaten.

10. **Food Web**
Pupils diagram the feeding interactions among populations of plants and animals. This diagram is called the **food web**. They investigate the role of humans in various food webs. They build an aquarium and study the populations in an aquatic environment. They identify predators and prey and construct food chains to describe the interactions of the populations.

## GRADE FOUR

Pupils learn to make planned and purposeful inquiries into the world around them. This includes processes of investigation and explanation.

UNITS OF LEARNING:

1. **Small Things**
   During this unit, pupils:
   - Learn to use and care for a microscope.
   - Become conversant with the terms related to the microscope.
   - Prepare slides of living and nonliving material.
   - Describe characteristic properties of specimens observed under a microscope.
   - Examine a variety of specimens to determine the existence of cellular structure.
   - Distinguish between different kinds of protozoa.
   - Gather information about scientists associated with early discoveries related to the microscope.
   - Establish that a microscope does not physically increase the size of the object being viewed.
   - Make accurate observations and record them in an organized format.

2. **Rocks and Minerals**
   During this unit, pupils:
   - Develop visual discrimination by isolating the common characteristics found in the rocks.
   - Make comparisons between known samples and those rocks collected in the field.
   - Use measurement as a practical tool in describing rock and mineral samples.
   - Make careful and precise observations and compare their observations with those of other students in the class.
   - Develop skills in recording information by making charts to categorize specimens.
   - Recognize the need for a standard system of classifications.
   - Conduct experiments to provide a detailed classification system.
   - Develop a classification system based on the observable characteristics of the rock samples.
   - Use reference materials to extend their investigations of rocks and minerals.

3. **Scientific Reasoning**
   a. Plane Sense
      During this part of the unit, pupils:
      - Identify variables in a model plane/flight line system that might affect flights.
      - Predict outcomes of various flights.
      - Set up experiments and gather data to answer questions.
      - Identify trends in experimental data.

   b. Swingers
      During this part of the unit, pupils:
      - Experiment with variables that do and do not affect the behavior of swingers (pendulums).

Discover that the length of the pendulum is the variable that determines the number of swings a swinger makes in a unit of time.
Graph the results of their experiments.
Move from a concrete to a picture graph.
Move from a picture graph to a two-coordinate symbolic graph.

c. The Force

During this part of the unit, pupils:

Rediscover the concept of magnetism and magnetic force.
Describe the magnetic force of repelling and attracting.
Explore the concept of measurement as it relates to magnetic force.
Predict, measure, and chart the force of varying space between attracting magnets.

d. Mystery Powders

During this part of the unit, pupils:

Make careful and precise observations and compare their own observations with those of other pupils.
Develop the ability to observe carefully, to discriminate differences and to describe characteristic properties.
Develop experimental skills while attempting to identify a variety of unknown white substances.
Establish working procedures which will prevent the contamination of substances under investigation.
Test the reactions of substances to water, heat, iodine, and vinegar.
Identify unknown substances by comparing observations of their characteristics with previously recorded information.

4. Crayfish

During this unit, pupils learn to:

Identify several typical behaviors of crayfish.
Record in writing or in pictures the activities of crayfish.
Identify the oxygen, water, space and/or temperature levels necessary for crayfish life.
Demonstrate correct methods for feeding and handling crayfish in the classroom.
Identify body parts of a crayfish.
Identify and describe the process of molting.
Measure and record the length and weight of a crayfish.
Conduct an investigation of crayfish reaction to light and identify stimuli that can be used to test crayfish reaction.
Describe typical feeding behaviors observed in classroom crayfish and determine the types of food preferred by classroom crayfish.
Devise a test to determine the social order that emerges when several crayfish share the same small territory.
Measure the holding strength of crayfish.
Determine the most dominant crayfish by charting movement in and out of a crayfish house.
Apply the major concepts developed in the unit: organism, birth, growth, development, death, habitat, life cycle, population, environment and community.

## GRADE FIVE

Pupils pursue further inquiries into areas not directly observable to the unaided senses and search for satisfactory explanations to their questions.

UNITS OF LEARNING:

1. **Batteries and Bulbs**
   During this unit, pupils develop the following major concepts while investigating electrical phenomenon. They use the scientific processes learned earlier in these investigations:
   - A circuit is made up of a source, a pathway, and a receiver of electricity. Electricity flows when these parts are connected.
   - Modifications to the source, pathway or receiver will cause changes in the electric flow.
   - There are two basic types of circuits. In a series circuit, electricity flows through each bulb consecutively. In a parallel circuit, electricity flows through each bulb separately.
   - Magnets interact with other magnets and with other objects.
   - Magnets interact at various distances.
   - Unlike poles of magnets attract. Like poles of magnets repel.
   - A magnetic force is associated with an electric current.
   - Electricity and magnetism are used to run many machines.
   - Electricity and magnetism are important forms of energy in everyday life.

2. **Astronomy and Space**
   During this unit, pupils will:
   - Become familiar with Astronomy and distinguish it from nonscience such as Astrology.
   - Examine the history of Astronomy, and the theories of early astronomers in explaining the universe.
   - Describe the relative size, position, and motion of the planets and sun in our solar system.
   - Learn some characteristics of the planets.
   - Describe the relative position of the moon to the earth during phases and eclipses.
   - Identify and use reference objects such as the North Star to locate and identify constellations.
   - Describe and compare comets, asteroids, and meterorites.
   - Become familiar with early attempts to fly and various vehicles used.
   - Become familiar with various manned space vehicles and the mission they were designed to achieve.

3. **Household Science**
   During this unit, the pupils will:
   - Further develop the concept of solution and mixture.
   - Learn the concept of chemical reaction.
   - Identify and describe evidence of reaction in liquid systems.
   - Learn that yeast are organisms that utilize sugars found in food.
   - Determine the relative amount of sugar in various substances through controlled experimentation.
   - Determine the relative amount of acid in a substance by measuring the amount of gas given off when it reacts with a specified amount of baking soda.

Investigate and identify cohesion, adhesion, and surface tension as properties of a liquid.
Investigate and describe capillary action.
Investigate and describe ways in which cohesion, adhesion, and surface tension are affected by the addition of other liquids such as soapy water.

4. **Patterns in Trees and Twigs**

During this unit, pupils:

Observe buds, twigs, branches and trees outdoors.
Observe and care for in the classroom twigs they have collected.
Compare the varying rates of twig development under different conditions.
Dissect and describe buds and bud clusters on twigs.
Identify and classify twigs, leaves, and trees based upon their properties.
Describe and identify the layers and rings within the tree's structure.
Examine and/or describe the internal and external characteristics of a tree's structure.
Devise and conduct tests on the budding of twigs.
Investigate water conduction in twigs, celery stalks or flowers.
Observe tree shapes and factors that determine them.
Name and describe different types of leaf margins, leaf form, and leaf arrangements.
Study variations of bark structure and function.

## GRADE SIX

Pupils inquire into current real world problems, issues and resolutions. Special attention is given to the human involvement in science.

UNITS OF LEARNING:

1. **Voyage of the Mimi**
   During this unit, pupils develop
   a. Skills of:
      Observations, as they -
      - Describe the physical characteristics of organisms (whales and mealworms).
      - Describe an organisms response to a variety of stimuli.

      Classifications, as they -
      - Discriminate between fact and inference when analyzing experimental data.
      - Assess which environmental conditions do or do not affect the behavior of an organism.
      - Compare fingerprint patterns.

      Measurement, as they -
      - Determine the length and weight of organisms using scale.
      - Determine location using latitude and longitude.

      Data collection and organization, as they -
      - Use computers to collect and record changes in systems.
      - Collect and systematically organize experimental data into simple charts and graphs.

      Inference and prediction, as they -
      - Predict mealworm behavior on the basis of observed data.
      - Infer whale migration patterns and causes.

      Variable identification and control as they -
      - Investigate and identify the environmental variables that affect the development and behavior of an organism.

      Making and testing hypotheses, as they -
      - Devise and conduct experiments to measure the effect of a variable in the system.

      Manipulation, as they -
      - Use a variety of tools and techniques to collect data.

      Communication, as they -
      - Describe the results of their activities and experiments.
      - Increase their vocabulary by using new words related to the study of science.
      - Discuss ideas and evaluate their work and the work of others.

   b. Concepts of:
      - Navigation, relative position, reference object, relative size, and scale.
      - Mapping, compass use and function, and orienteering.
      - Food chains, habitat, population, and environmental factors.
      - Organism structure, function, and behavior.
      - Sound frequency and pitch, and temperature/heat.
      - Water pressure, displacement, floating and buoyancy.
      - Hypothermia, weather phenomena, the water cycle.
      - Technology available to solve real world problems.
      - Specialized communications forms because of special needs or technical information demands.

c. Attitudes of:
- Science as a human endeavor.
- Careers available to men, women, minorities, and handicapped people of all ages.
- Value of scientific thinking in the areas of consumerism and personal decision-making.
- Contributions of men, women, minorities, and handicapped people through investigations in science.
- Concern and support for stewardship efforts to safeguard planet Earth from environmental destruction.
- A continued interest in furthering their science education through elective courses and independent reading.

2. **Simple Machines** (LEGO)
During this unit the pupils will:
- Understand that humans have developed simple machines to make their work easier.
- Know the five simple machines and their characteristics.
- Be able to recognize the practical applications of simple machines.
- Recognize that simple machines make work easier, but do not save work.
- Recognize that a simple machine may change the direction of a force, multiply a force, transfer a force from one place to another, or increase speed with which work is done.
- Be able to use gears/belts in combinations to transfer/multiply forces.
- Recognize that friction is a factor in the operation of all machines.
- Recognize that friction has advantages and disadvantages.
- Be able to transfer two-dimension drawings to three-dimension constructions.

3. **Science World**
During this unit, pupils will develop
- An awareness of science in everyday life.
- An understanding of science related issues facing consumers and citizens of planet Earth.
- A positive attitude toward the progress being made to resolve the science related issues and their role in its process.
- Discrimination skills in evaluating scientific data and evidence presented in various media.
- An awareness of the role science plays in their daily life.
- An awareness of careers available to them.

RECOMMENDED RULE CHANGES
IN GRADUATION REQUIREMENTS
AND
MINIMUM PROGRAM OFFERING

PRESENTED TO:

Dr. Ruth Randall, Commissioner of Education
and
Members Minnesota State Board of Education
July 1988

6-8-88

# ENVIRONMENTAL EDUCATION

## I. Learner Outcomes

Every district must provide the opportunity for every student to develop the knowledge, skill, and affect to:

A. Understand ecological systems
B. Develop personal appreciation, sensitivity, and stewardship for the environment.
C. Understand cause-and-effect relationships between humans and the environment.
D. Understand the decision-making processes of individuals and institutions.
E. Evaluate alternative responses to environmental concerns or issues before deciding on a course of action or no-action.
F. Understand ways in which planning/non-planning influences the future.

## II. Minimum Program Offerings

Every district will integrate opportunities for every learner to achieve I above in all K-12 curricular areas provided by the district.

## III. Graduation Requirements

None. Graduation requirements are met through developing the knowledge, skill and affect defined in I. above in other content areas.

The statement below is taken from the Minnesota State Department of Education document, Some Essential Learner Outcomes In Environmental Education, Fall, 1977 (p. 5). It describes the contexts in which environmental education is to be taught. It is followed by a listing of the dimensions of environmental education found within the District No. 11 elementary school science program. The specific attributes of our program are listed in the categories of awareness, knowledge, or skill. Because the development of a global environmental ethic requires many experiences and significant reflection on the part of the learner, time and maturity are required if a sense of responsibility and a commitment to the future is to be internalized in each of our young citizens. Teachers are encouraged to promote the social and valuing discussions and action in each appropriate situation.

***The Environmental Education Contexts:***

*Four Organizing Principles Which Define the General Topography for Curriculum/Instruction in Environmental Education*

*The contexts are useful for determining the diversity of environmental education experiences. An effective program should provide experiences in all contexts over a period of time. Which context is emphasized at a particular time or age level is an open question. One could establish a progression of learning experiences through the context from natural to action. However, multiple entry points for learning experiences would also seem to be possible. These programming decisions depend upon several variables such as the complexity of the learning experience and the age and sophistication of the students.*

1. ***Natural Context:***

   *That learning which is most related to nonhuman dominated communities and their physical habitats, including, e.g., soils, atmospheric and hydrologic systems, animals, plants, the distribution and abundance of organisms, decomposers and decomposition processes, nutrient and mineral cycles and energy systems.*

2. ***Social Context:***

   *That learning which is most related to social, economic, political, cultural, ethical and psychological systems.*

3. ***Valuing Context:***

   *That learning which is most related to choosing freely from a thoughtful consideration of alternatives, becoming aware of what we cherish and affirming these choices by connecting them to our own overt behavior. Values clarifying questions are "you" questions. What does it mean to you? What difference has this made in your life? What did you learn that was important to you? How do you live differently as a result of what you have learned?*

4. ***Action Context:***

   *That learning which is most related to the identification, evaluation, and testing of alternatives to community environmental problems, the political and social communication skills required and their resolution and service to the community.*

***Discussion of Context:***

*The natural and social contexts relate directly to one's understanding, or the cognitive aspect of learning. Perhaps it can be described as the total of one's experiences related to the acquisition of information, skills and processes.*

*The valuing and action contexts relate to the affective aspects of learning, thereby greatly influencing what we do with our understanding. It is probably not enough to believe something is true, for to consider action requires that a belief has value or worth to the individual. An individual's constructive behavior associated with the Action Context may be viewed as resulting from values acquisition which has high worth to the individual.*

# Environmental Education Outcomes within the Science Instructional Program
## Grade 1

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Use of all senses to observe the world<br>Animal differences and types: guppies, snails, daphnia<br>Plant differences<br>Changes in plants and animals | Properties of living, dead, and non-living objects<br>Animal properties<br>Animal interactions (food chains)<br>Plant differences<br>Seeds as potential plants<br>Material differences in objects | Careful observation<br>Use of magnifiers<br>Classification<br>Ordering<br>Discrimination of property differences |
| SOCIAL | Planned home activities such as a family garden is suggested. | | |
| VALUING | Classroom and family discussions about the role of plants and animals in our lives | | |
| ACTION | Create an aquatic habitat<br>Leaf collections | Procedures for assembling the components of an aquarium | Build and maintain an aquatic habitat |

## Grade 2

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Chemical changes can occur (rusting of steel wool)<br>Objects can interact at a distance (sun and light sensitive paper; magnets; etc.)<br>Changes in temperature, color, et cetera as evidence of interaction<br>Crystal formation<br>Static electricity and sound are examples of interaction at a distance<br>Sounds can tell us about our environment<br>Role of environmental factors in seed germination<br>Growth versus development<br>Animal responses to environmental factors | Property-object-material<br>Change can occur in an object<br>Objects can interact<br>Systems concept<br>Dissolve, evaporate, and filter as evidence of interaction<br>Organism<br>Alive - dead - non-living<br>Similarities/differences between plants and animals<br>Fruit/seed<br>Life cycle of plants and animals<br>Seed germination - parts and roles<br>Mold as evidence of decay<br>Hydroponics/soil as plant systems<br>Seed dispersal mechanisms<br>Biotic potential<br>Life cycle stages; metamorphosis | Ordering<br>Classification<br>Prediction<br>Identifying evidence with interaction<br>Keeping track of a system<br>Observation<br>Discrimination |
| SOCIAL | People interact with each other in many ways<br>People interact with their environment | Human-made sounds can carry messages<br>Plants and their role in our lives: food, oxygen<br>Identifying local "weeds"<br>Safety in school and home | |
| VALUING | Sounds can be pleasant or unpleasant<br>Hydroponics as a commercial venture<br>Plants as "weeds"<br>Chemicals as poisons | | Recognize "Mr. Yuk" |
| ACTION | Wind direction and speed can be affected by objects in the environment. | | Use thermometers to measure temperature of systems (weather)<br>Build instruments to determine wind direction<br>Plant seeds<br>Grow plants in hydroponic systems<br>Maintain animal habitats<br>Label harmful chemicals in the home with "Mr. Yuk" stickers |

## Grade 3

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Chemical interactions<br>Turbidity<br>Schlieren as evidence of interaction within systems<br>Density of solutions<br>Buoyancy of objects<br>Fresh versus salt water<br>Environmental factors<br>Experimenting<br>Plants and animals share environments<br>Large number of organisms in areas (ponds)<br>Variation in organism growth rates<br>Population dispersal and barriers<br>Population changes<br>Predator-prey relationships<br>Predator features<br>Prey survival features | System-subsystem-interacting systems<br>Electrical interaction<br>Mixtures and solutions, non-solutions<br>Separating mixtures and solutions<br>Concentration<br>Variables within systems<br>Organisms requiring "salty" water (brine shrimp)<br>Growth versus development<br>Population as a concept<br>Food chain<br>Biotic potential<br>Generations<br>Food webs<br>Plant eaters<br>Predator-prey | Manipulate liquid systems<br>Screen, filter, or evaporate to separate systems<br>Paper chromatography to separate a mixture<br>Classification of water environments<br>Observe and compare organisms<br>Determine populations in an area |
| SOCIAL | Use of symbols to communicate data and relationships<br>Role of agriculture | Construct and use histograms to communicate data and relationships | |
| VALUING | Predator-prey relationships in nature (survival mechanisms)<br>Role of predators and population control<br>Role of humans in food webs | | |
| ACTION | | | Use thermometers and temperature strips to measure temperatures<br>Build and maintain terraria and aquaria |

## Grade 4: Crayfish Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Natural crayfish habitat<br>Crayfish feeding habits and requirements<br>Territorial behavior and interactions: dominant, social order<br>Structure-function relationships of crayfish anatomy<br>Molting processes and reasons<br>Species differences | Organism structures (crayfish)<br>Role in food chains - ecosystems | Proper handling techniques |
| SOCIAL | Recognize the human responsibility to provide appropriate care to animals in captivity<br>Human territorial behaviors | | |
| VALUING | Reduce anxiety toward an unfamiliar organism through familiarity and caring for it | | |
| ACTION | Locate crayfish habitats<br>Release crayfish in appropriate habitats at the conclusion of the study | | Handling of crayfish for further study |

## Grade 4: Rocks and Minerals Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Rock differences<br>Rock components<br>Rock origins<br>Rock cycles (change over time)<br>Dynamics of weathering processes<br>Mineral and crystal components<br>Factors involved in crystal growth and size<br>Natural crystal formations | Properties of rocks<br>Types of rocks<br>Differentiate between rocks, minerals, crystals<br>Rock composition | Observation<br>Classification<br>Observational techniques: streak plates, scratch tests, etc. |
| SOCIAL | Role of minerals in society, technology, culture<br>Occupations: geologist | | |
| VALUING | Importance of minerals<br>Determining and assigning value to minerals | | |
| ACTION | Collect rock specimens (agates, fossils, etc.) | | Determine hardness level<br>Conduct tests to determine composition of rocks |

## Grade 4: Scientific Reasoning Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Energy in a system<br>Periodic motion (pendulum)<br>Magnetism as a force<br>Interaction of substances<br>Physical versus chemical properties | Repel/attract<br>Cause/effect<br>Results of testing to determine unknowns | Identifying variables<br>Experimenting<br>Predicting<br>Charting<br>Data analysis |
| SOCIAL | Graphing as a communication device | | |
| VALUING | Need for critical thinking, careful observation, planned procedures, accurate note-taking and data recording | | |
| ACTION | | | Determine strength of a magnet<br>Determining the composition of a mystery powder mixture |

## Grade 4: Small Things Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Microscopic world<br>Cell components (water)<br>Field<br>Minute properties of objects<br>Perspective<br>Staining to increase observable features<br>Crystal structure and growth<br>Cell division - "budding" | Cell structure<br>Magnification<br>Compound microscope<br>Plant versus animal cell structure<br>Protozoa examples<br>Cells as indicators of living objects | Use of tools: microscope, balances<br>Slide preparation<br>Identifying three micro-organisms<br>Determining amount of water in the cell<br>Determining population level of a microscopic organism (yeast) |
| SOCIAL | Occupations: microbiologist<br>Scale and representation as communication devices<br>Human role in science exploration, discovery, and invention<br>Historical perspective<br>Technological developments | | |
| VALUING | Contributions of predecessors<br>Problem-solving successes/failures<br>Need for persistence, curiosity, inventiveness, open-mindedness, critical thinking | | |
| ACTION | | | Use of compound microscope<br>Preparing specimens for viewing<br>Cell measurement and comparison |

## Grade 5: Astronomy and Space Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Size/distance relationships<br>Relative positions<br>Relative motions<br>Perspective<br>Reference object<br>Constellation identification | Components of the solar system<br>Characteristics of planets<br>Earth/sun motions and relationships<br>Rotation, revolution, axis, orbit, year, day<br>Moon phases<br>Eclipses<br>Planetary exploration | Use devices to investigate earth/sun motions<br>Use devices to locate constellations |
| SOCIAL | Astronomy as a science<br>Astrology as a non-science<br>Historical development of astronomy<br>Use of time line in understanding events<br>Constellation identification and naming<br>Potential careers | Role and contributions of selected astronomers<br>Some interpretations of celestial observations<br>History of human flight<br>Space explorations | |
| VALUING | Technological advancements and spinoffs to human kind related to space exploration and initiatives | | |
| ACTION | Identifying course selection for future space science careers | | |

## Grade 5: Batteries and Bulbs Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Electrical transmission<br>Chemical reactions yield electrical energy<br>Resistance to electrical conduction in various materials<br>Magnetism/electricity relationships | Circuit: complete, open, short, parallel, series<br>Conductor<br>Insulator<br>Bulb components<br>Battery contents/components<br>Fuses/circuit breaker<br>Operation of a compass | Construct circuits<br>Test electrical conductors<br>Measure brightness<br>Infer electrical connections using evidence<br>Construct an electromagnetic |
| SOCIAL | Use of electricity<br>Safety in electricity<br>Communicating using symbols | | |
| VALUING | Importance of electrical energy | Importance of fuses and circuit breakers in electrical circuits | |
| ACTION | | | Determine the wiring pattern in a mystery box<br>Determine conductivity of various objects<br>Determine amount of electrical flow in various circuits using a brightness meter |

## Grade 5: Household Science Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Chemical reaction<br>Organism (yeast interacts with sugar to produce a gas)<br>Dormant as an organism state<br>Acid indicator<br>Cohesion, adhesion, surface tension<br>Factors that affect the properties of liquids | Solution<br>Cause/effect relationships<br>Testing procedures<br>Need for a "control" in experimenting<br>Properties of liquids | Accurately measure liquids, solids, gases<br>Make careful observations<br>Read graduated cylinders |
| SOCIAL | Producer/consumer relationships in human society | | Agree on conclusions based upon data analysis |
| VALUING | Effective advertising on consumer actions | | Determine accuracy of consumer product labeling regarding sugar content<br>Evaluate results and conclusions based on "best" methods |
| ACTION | | | Determine sugar content of various foods<br>Determine acid strength of various food<br>Determine amount of a property of a liquid |

## Grade 5: Patterns In Trees and Twigs Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Growth pattern of branches<br>Growth rates<br>Environmental factors affecting growth rate and patterns<br>Water conduction processes | Tree crowns can be described and used to classify trees<br>Bud features, development<br>Twig growth, study, features<br>Age determination<br>Leaf characteristics and arrangements<br>Bark characteristics<br>Growth rings<br>Two main tree groups<br>Parts of a tree | Observation<br>Classification<br>Inference<br>Identifying a tree |
| SOCIAL | Communicating about wood and identifying confusing terms such as hardwood and softwood<br>Uses of trees by the Chippewa Indian people | | |
| VALUING | Wood uses<br>Importance of trees to the Chippewa Indian people | Preferred branching arrangement for various purposes | |
| ACTION | | | Determine age of a tree using growth rings<br>Infer growth factors |

## Grade 6: Science World Unit

(Example from Volume 44, No. 6, November 20, 1987)

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Potato skin poisons<br>Arctic dinosaurs<br>Essential trace elements (diet)<br>Komodo monitor lizard<br>Acne | | |
| SOCIAL | Adopt a killer whale<br>High protein breakfast<br>A research recipe for a healthy global diet<br>Superconductivity<br>People in science: Dr. Mary Musgrave, Space Biologist | | |
| VALUING | Purposes for superconductors | | |
| ACTION | | | |

## Grade 6: Simple Machines Unit

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Relationships between work, force, friction, motion<br>Centrifugal/centripetal force<br>Mechanical advantage | Work<br>Simple machines - lever, inclined plane, wheel and axle, pulley, and screw<br>Friction | Constructing models<br>Reading diagrams |
| SOCIAL | Use of machines<br>Historical development of machines<br>Applications of principles to common, useful devices<br>Role of technology in human energy problems | | |
| VALUING | Locate examples of simple machines within common life experiences and devices | | |
| ACTION | | | Develop devices using the materials provided to demonstrate the principles taught: gear ratio, steering types and mechanisms, levers, etc. |

## Grade 6: Voyage of the Mimi

| | AWARENESS | KNOWLEDGE | SKILL |
|---|---|---|---|
| NATURAL | Latitude/longitude<br>Triangulation processes<br>Orienteering<br>The ocean in our daily lives<br>Mammal adaptations to the marine environment<br>Water pressure<br>Animal behavior patterns<br>Sound: source, transmission, receiver, application, frequency<br>Temperature differences in water<br>Feeding behavior of whales<br>Animal behavior/environmental condition relationships<br>Ocean pollution<br>Interrelationships between marine organisms and humans<br>Organism adaptations to marine environments<br>Whale migration and communication<br>Feeding needs<br>Weather: conditions, study, factors<br>Hypothermia: symptoms, causes, treatment<br>Survival techniques<br>Human body temperature regulation mechanisms<br>Wind chill<br>Solar still operation<br>"Red tide" causes and effects<br>Forging for food in the wild<br>Density, displacement, buoyancy | Reference objects used on navigation charts<br>Functioning of a compass<br>Scale<br>Characteristics of whales<br>Temperature and heat<br>Insulation and heat loss<br>Fahrenheit/Celsius comparisons<br>Need for fresh water in human survival<br>Evaporation/condensation as a water purification method<br>Food chains | Compass use<br>Reading a navigation chart<br>Determining position<br>Careful observation<br>Use of computers to collect sounds<br>Sampling procedures<br>Use of temperature sensing devices<br>Determining the density of an object |
| SOCIAL | Sign language as a means of communication<br>Technical language from specialized areas<br>Nature of science<br>Work of marine biologists<br>Types of instruments on sailing vessels<br>Use of computers in scientific investigation<br>Oil spills<br>Gallaudet college<br>Ways of compensating for deafness in day-to-day life<br>Work of meteorologists<br>Environmental medicine studies<br>Role of technology in society<br>Organic gardening, composting, solar heating as societal alternatives | Science as a way of knowing<br>Specialized science terms: observation, inference, hypothesis, theory, fact, data | |
| VALUING | Contributions of all people: young, old, handicapped, male, female<br>Importance of mapping the ocean floor<br>Significance of marine biology research<br>Gallaudet college value<br>Value of individual strength contributions to a group effort<br>Individual value system influence on professional work<br>Value of research to society | | |
| ACTION | | | Collect and classify fingerprints<br>Use modern technology to collect and analyze data |

## NONCURRICULAR ENVIRONMENTAL EDUCATION RESOURCES

### BOOKLETS AND BROCHURES
(Listed Alphabetically by Agency)

Acid Rain Foundation Inc.
1630 Blackhawk Hills Road
St. Paul, MN 55122
(612) 455-7719

Acid Rain in Minnesota - 20 page booklet prepared by MPCA. $3.00 per copy.
Student Packet on Acid Rain - General information on acid rain. $5.00.
Acid Rain Coloring Book - Called "Rain, Rain Go Away" for young children. $3.00 per copy.
Tree Cores - Borings from a red spruce tree ready for finishing. $10.00

Ag-In-The Classroom
90 West Plato Boulevard
St. Paul, MN 55107
Al Withers, Coordinator
(612) 296-6688

Minnesota Agriculture Statistics 1986 - A detailed synopsis of our agricultural industry. Available from Minnesota Extension Service, Distribution Center, 3 Coffey Hall, St. Paul Campus, University of Minnesota, St. Paul, Minnesota 55108. $5.00.
"The Big Brown Bag" - A 64 Page booklet on food consumption and agricultural economics. $3.50. Available from Food Marketing Institute, 1750 K Street N.W., Washington D.C., (202) 452-8444

Minnesota Conservation Federation
1036 - B Clevland Avenue South
St. Paul, MN 55116

National Wildlife Week Teachers Kit - Packet of information and activities on wildlife and conservation, printed annually in late winter.

Minnesota Department of Natural Resources
500 Lafayette Road
St. Paul, MN 55155
Bureau of Information and Education, Box 46
Division of Forestry, Box 44

Smokey The Bear - a variety of education materials.

Nongame Wildlife Program, Box 7

Winter Bird Poster
Woodworking For Wildlife - A 47 page booklet describing shelters for 40 wildlife species, with detailed construction plans included. Now available at cost from Division of Document, 117 University Avenue, St. Paul, Minnesota 55155.

Source: Catalog of Elementary Environmental Education Resources; Minnesota Curriculum Services Center, 3554 White Bear Avenue, White Bear Lake, MN 55110; pp. 83-94.

Minnesota Environmental Quality Board
Room 110 Capitol Square Building
St. Paul, MN 55101
(612) 296-2723

Environmental Review - How the state environmental review process works.
Environmental Issues and Feedlots - Booklet on environmental impacts of feedlots.
Minnesota Environmental Quality Board - Brochure details the Board and its programs.
Minnesota Environmental Directory - 1986 - Names of environmental agencies, groups and programs.
Groundwater in Minnesota - 64 page book on groundwater.
Power Plant Siting - Brochure describing procedures for power plant and power line siting.

Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55101
Dale Newton
(612) 296-7373

Breaking the Landfill Habit - 6 informative sheets on alternatives to landfills.
MPCA Pollution Fighters Handbook - Comic/Coloring book of 10 pages on general pollution topics.

Minnesota Zoo
Apple Valley, MN 55124
Membership Department

Minnesota Zoo Magazine - Subscription $10.00 a year, 6 issues a year. Features animals, activities and people at the zoo.

Northern States Power Company
414 Nicollet Mall
Minneapolis, MN 55401

Enerjeanie and The Magic Word - Free to primary teachers in NSP service area.

U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, MN 55111
Tom Worthington
(612) 725-4689

Brochures, bulletins, maps for all wildlife refuges in the National Wildlife Refuge System.

Waste Management Board
Public Information Office
7323 58th Avenue North
Crystal, MN 55428
(612) 536-0816

Waste Management Board Fact Sheets - Information sheets on various subject dealing with solid and hazardous wastes.
Household Hazardous Waste Fact Sheet Information on common household wastes and how to dispose of them.
Home Sweet Hazardous Waste - A color brochure identifying the problem and offering disposal guidelines.

## DIRECTORIES AND BIBLIOGRAPHIES
(Listed Alphabetically by Agency/Source)

The Acid Rain Foundation
1630 Blackhawk Hills Road
St. Paul, MN 55122
(612) 455-7719

International Directory - 400 scientists, educators and policy experts who will speak on acid rain. $8.00.

Resource Directory (1985) - Listing of public, private and educational resources available from industry, government, environmentalist and public interest groups. $10.00.

Acid Deposition Bibliography - Listing of scientific papers, symposia, books and pamphlets on acid rain. Useful for student research. $8.00.

Ag-In-The Classroom
90 West Plato Boulevard
St. Paul, MN 55107
Al Withers
(612) 296-6688

Resource Guide to Educational Materials about Agriculture - Designed to show where information is available on all phases of agriculture. Single copies free.

A Directory of Environmental Education
Facilities in the Twin Cities Area
Alan Singer

Discover Nature in the Twin Cities - A resource directory of 29 Nature Centers, museums, 200 parks and refugees which offer EE programs to schools. Available in most Twin Cities bookstores. $4.50.

Minnesota Pollution Control Agency
1935 West County Road B-2
Roseville, MN 55113
(612) 296-7373

Teachers Guide: Educational Materials in Resource Recovery: Grades K-12 Nationwide listing of curricula, books and audiovisual materials available on resource recovery.

National Audubon Society
North Midwest Regional Office
Suite 330 City Place
730 Hennepin Avenue
Minneapolis, MN 55403
(612) 375-9140

Project Egret - A looseleaf notebook with curriculum samples and ideas on education projects. Includes a nature center directory for Minnesota, Wisconsin, Iowa, North Dakota and South Dakota. $5.00.

## FACILITIES FOR ENVIRONMENTAL EDUCATION
(Listed Alphabetically by Name)

Audubon Camp in Wisconsin
National Audubon Society
North Midwest Regional Office
Suite 330 City Place
730 Hennepin Avenue
Minneapolis, MN 55403
(612) 375-9140

Description - A camp located on 335 acres near Spooner, Wisconsin. It features deciduous forest, rolling meadows, lakes and bays. Camp program is in the summer and the class sessions are set. Some college credit classes available.

Belwin Outdoor Education Lab
1553 Stagecoach Trail South
Afton, MN 55001
Sharon Eaton, Director

Description - A nature center for St. Paul and Stillwater Public Schools only. A 320 acre site with a nonresidential program.

Deep Portage Conservation Reserve
Route 1, Box 129
Hackensack, MN 56452
Mike J. Naylon, Director
(218) 682-2325

Description - A public demonstration and education site on 6100 acres including 26 miles of trails, 5 lakes and 2 rivers. Resident programs from 2-5 days available in 1987.

Dodge Nature Center
1795 Charlton Street
West St. Paul, MN 55118
Jim Malkowski, Director
(612) 455-4531

Description - A day facility dedicated to the education of students and adults about their environment. The site includes 360 acres of mixed habitat and a model farm.

Eastman Nature Center
11351 Elm Creek Road
Osseo, MN 55369
Tom McDowell, Director
(612) 420-4300

Description - A nature center facility which provides high quality environmental education to schools. Features trails, pond study area, classroom exhibits, displays and a reference library.

Lake Carlos Environmental Center
Route 5, West Lake Carlos
Alexandria, MN 56308
Kurt Marple, Director
(612) 846-2431

Description - A residential year-round camp located 7 miles north of Alexandria, Minnesota. Can house 120 students. Site features lake, marsh and maple - basswood forest.

Lowry Nature Center
Carver Park Reserve
7025 Victoria Drive
Excelsior, MN 55331
Roger Stein, Director
(612) 472-4911

Description - A nature center in Carver Park with a site of 450 acres. Site features woods, wetlands and meadows. Eight miles of clipped trails. Staff provides instruction for students and teachers.

Minnesota Zoo - Education Department
Apple Valley, MN 55124
Pam O'Brien, Coordinator
(612) 432-9010, Extension 218

Description - Programs for K-12 from September through April without charge with advance registration. Several topics including learning excursions, tours, self-guided experience and foreign language units.

Mountain Iron - Buhl Environment Learning Laboratory
John Lindquist
22 Greenwood Lane
Mount Iron, MN 55768
(218) 735-8763

Description - A facility of 40 acres at Merrit Elementary School. It is available to Arrowhead Region Schools only. There are 5 ecotypes and a connecting trail at the site.

Northwoods Audubon Center
Route 1, Box 288
Sandstone, MN 55072
(612) 245-2648

Description - A year-round environmental education center. Located on 535 acres of forest land in Pine County. Serves as a field campus for U of M - Duluth and Northland College, Ashland, Wisconsin.

Northwoods Resource Center
Widjiwogan/St. Paul YMCA
1761 University Avenue
St. Paul, MN 55104
Robert Rich - Executive Director
(612) 645-6605

Description - A residential environmental education camp located 17 miles north of Ely, Minnesota. Programs for school grades 4-12. Advocates a strong wilderness etnic.

Red River Valley History Area
Natural Resource Department
University of Minnesota Technical College
Crookston, MN 56716
Dan Svedarsky or Tom Feiro
(218) 281-6510, Extension 310 or 312

Description - An 85 acre site offering a variety of habitats representative of the Red River Valley. Wetlands, marsh, cottonwood, lowlands characterize the area. A portion of the area is accessable to handicapped. A one room nature center is available.

St. Croix Environmental Center
YMCA Camp St. Croix
County Road F
Hudson, WI 54016
Patty Mueller, Program Director
(612) 436-8428

Description - A residential environmental education center on a 400 acre site. Winterized buildings can accomodate up to 150 students for a 2-5 day period. Located 20 miles east of St. Paul.

U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, MN 55111
Tom Worthington
(612) 725-4689

There are seven National Wildlife Refuges in Minnesota. Some accommodate school groups. Almost every one has some facilities for environmental education and nature study, but not all are guided.

## SLIDE AND VIDEOTAPE PROGRAMS
(Listed Alphabetically by Agency/Source)

Ag-In-The Classroom
90 West Plato Boulevard
St. Paul, MN 55107
Al Withers, Program Coordinator
(612) 296-6688

The Land is a Giant - 7 minute videotape or 16 mm film on the diversity of Minnesota agriculture.

Minnesota on the Move - 15 minute videotape or 16 mm film about the transportation system available to Minnesota grain producers, and the logistics of exporting grain to principal ports.

Karlyn Atkinson-Berg
Route 2, Box 225A
Bovey, MN 55709
(218) 245-3049

Wildlife, Wolves and Wilderness - A variety of slide programs on wolf ecology and behavior.

Death of a Legend - 45 minute film on wolves.

Environmental Resource Development
101 Capitol Square Building
St. Paul, MN 55101
(612) 297-3190

Industrial Beautification - A slide show about the benefits of industrial beautification.

The Environmental Consumer (Recycling) - A slide presentation on students role in recycling.

Minnesota Department of Natural Resources
500 Lafayette Road
St. Paul, MN 55155

Bureau of Information and Education, Box 46, 16 mm films, videotapes, slides and cassettes on every resource subject. Too numerous to list; contact Box 46 for titles.

Nongame Wildlife Program, Box 7

Frogs and Toads, Snakes, Lets Talk Turtles, Hello, I'm a Loon, The Prairie Chicken in Minnesota, Bluebirds; Bring Them Back, The Piping Plover: An Endangered Species, Bat Conservation - Slide and cassette sets available from the Bureau of Information and Education, Box 46.

Two Little Owls, The Landfill Crane Story, Peregrine, Bluebirds - 16 mm films available from the Bureau of Information and Education, Box 46.

Minnesota Environmental Education Board
500 Lafayette Road, Box 5
St. Paul, MN 55155

Crises In The Rain - 16 mm film (28 minutes). Upper elementary and up. Introduction to the origins and significance of the problem.

Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55101
Contact the film library for titles.

MNTAP - University of Minnesota
West 163 Boynton Health Services
Minneapolis, MN 55455
(612) 376-4962 or (800) 247-0015
Minnesota Technical Assistance Program - 15 minute slide program on business management of hazardous wastes.

U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, MN 55111
Tom Worthington
(612) 725-4689
Call for information on the film library.

Waste Management Board
Public Information Office
7323 58th Avenue
Crystal, MN 55428
(612) 536-0816
Ask Mr. Waste - 29 Minute videotape which answers questions about waste management.
Household Hazardous Waste - 10 minute slide show defining the problems of household hazardous wastes. Also lists alternative products.
In Minnesota - We Care - 15 minute videotape outlining the problems associated with household hazardous waste.

**THEATRICS AND INDIVIDUALS/PROGRAMS**
(Listed Alphabetically by Agency or Individual)

Karlyn Atkinson-Berg
Route 2, Box 225A
Bovey, MN 55709
(612) 245-3049

Description - Programs for all ages on wildlife. Emphasis on Wolves. Wolf howling included.

CLIMB Threatre
529 Jackson Street
Suite 227
St. Paul, MN 55101
(612) 227-9660

Description - Creative Drama residences various target groups on a variety of subjects. Residences from 1 to 12 weeks anywhere in Minnesota. Fees based on services requested.

TRASH - A dramatic production to introduce concepts of waste reduction, reuse and recycling. Available throughout Minnesota.

Minnesota Pollution Control Agency
1935 West County Road B-2
Roseville, MN 55113
Cathy Berg Moeger
(612) 296-7324

Description - Speakers, liaison, technical advice on curricula on solid waste management. Available to teachers.

Minnesota Zoo
Speakers Bureau
Apple Valley, MN 55124
(612) 432-9010

Description - 35 to 45 minute program on 10 topics including slides. Presented by Zoo volunteers. Limited to Metro area. Three week advance reservations required.

Emily Moore
4055 Colfax Avenue
Minneapolis, MN 55409
home: (612) 824-3184
work: (612) 296-7325

Description - A presentation including measurement and story telling to help children learn the oxygen/carbon cycle in a conceptual way.

Nature on Wheels
Larry Wade
5901 Mahonay Avenue
Minnetonka, MN 55345
(612) 934-6458

Description - A science resource. A teacher who works with individual classes. Topics include: Whales in the Classroom; Make Your Own Comet. Preschool to grade 8. Fee $25.00 per presentation. Other services available.

Dennis Olson
2329 Ditchback Road
Cloquet, MN 55720
(612) 879-8746
or
Minnesota Loon Preservation Project
806 Torrey Building
314 Superior Street
Duluth, MN 55802
(218) 722-3514
or
Sigurd Olson Institute
Northland College
Ashland, WI 54806
(215) 682-4531 Extension 491

Description - Creative dramatics to teach environmental concepts. Character portrayals include: Critterman, Dr. Death, Professor Avian Guano, Professor Gavia Immer.

Science Museum of Minnesota
Interpretation Department
30 East 10th Street
St. Paul, MN 55101
Eileen Flory
(612) 221-9428

Description - Demonstrations available in the museum, Anthropology Hall. On topics such as: everyday life of the Maya tools: past and present. Teacher resource materials are available. Our Minnesota exhibit in the museum includes demonstrations on Minnesota geography and land use. By reservation only.

Doug Wood - Earth Song
104 4th Street North
Sartell, MN 56377
(612) 253-8211

Description - Programs of environmentally oriented music, guitar and song. Programs for school include audience participation.

## WORKSHOPS, SEMINARS, AND SCHOOLS
(Listed Alphabetically by Agency/Sponsor)

CLIMB Threatre's Residency Company
Grey Rybak
529 Jackson Street, Suite 227
St. Paul, MN 55101
(612) 227-9660
Description - Workshops on creative teaching techniques using dramatics.

MN Sea Grant
208 Washburn Hall
University of Minnesota - Duluth
Duluth, MN 55812
Description - Aquatic workshops for Educators. Statewide workshops designed to provide activities which can be used in classroom or outdoors. Nominal fee charged.

Minnesota Zoo
Pam O'Brien
School Program Coordinator
Apple Valley, MN 55124
(612) 432-9010
Description - Workshops for teachers to prepare them for conducting more effective field trips to the Zoo.

Northwoods Audubon Center
Route 1, Box 288
Sandstone, MN 55072
(612) 245-2648
Description - Naturalist training is a 4 day course for parents, teachers, etc. interested in learning more about Environmental Education.
Northwoods Wilderness School is a summer youth ecology camp combining ecological concepts with outdoor adventure skills.

University of Minnesota
Dr. Gene Gennaro
320 Peik Hall
Minneapolis, MN 55455
Description - Graduate Summer School Course - Teaching Minnesota Environmental Issues, Elementary 5 - 347, Section 2. Topics include water quality, toxic waste and ground water.

Wilder Forest
Description - 1 day seminar to increase awareness of the connections between people and the urban, rural and wilderness environments. Only available to St. Paul schools.

## ELEMENTARY ENVIRONMENTAL EDUCATION RESOURCES OTHER THAN CURRICULUM

"Food For America" - FFA Tells The Story, National FFA Center, P.O. Box 15160, Alexandria, Virginia 22309, 1-703-360-3600.

A complete set of materials (packet) for K-3/4-6 for use by vo-ag teachers and FFA students to help further educate elementary school children. Designed to create on understanding of food production and distribution and to show some of the career opportunities open to young people in agriculture today. First kit free, additional $3.25 each.

"Resource Guide to Educational Materials About Agriculture". Contact Al Withers, Minnesota Ag-In-The Classroom, 90 West Plato Boulevard, St. Paul, Minnesota 55107, (612) 296-6688.

A USDA publication to make more visible agriculture related resources and information to educators. Centers around 7 key concepts the USDA covers with Ag-In-The Classroom (Ag and History - Ag and Geography - Ag and Technology - Economics of Ag - Ag and The World - Careers - Major Policy Issues). Available free from USDA, Ag-In-The Classroom or by contacting Al Withers.

"The Science Workbook", Dr. Ted Darrow, The College of Agriculture, Ohio State University, 2120 Fyffe Road, Columbus, Ohio 43210.

Intended to be a handbook for high school and middle school science teachers and students. The workbook is a compilation of exciting student research projects in Food, Agriculture and Natural Resources. Available for a fee.

## ELEMENTARY SCHOOL SCIENCE PROGRAM: LIVE ORGANISMS

### GRADE ONE

Shipment A

10 large, mature male guppies (not Gambusia)
26 large, mature female (not Gambusia)
18 pond snails (Physa or Lymna)
1 jar Duckweed
1 jar Chlamydomonas algae culture or other single-celled algae (filamentous algae not acceptable)
16 springs of Anacharis
1 package Eel grass

Shipment B

Daphnia magna culture (150). The daphnia should be mature with many individuals approaching 1/8 inch in length.

### GRADE TWO

Shipment C

100 frog eggs
1 container tadpole food
250 mealworm larvae (late larva preferred)
1 lb. mealworm food (bran)

Shipment D

20 fruit fly cultures (capped vials)

Shipment E

2 butterfly cultures (provide name also, i.e., Painted Lady, etc.)

### GRADE THREE

Shipment F

2 pints established Chlamydomonas algae culture (or other single-celled algae, filamentous algae not acceptable)
1 jar Daphnia magna culture (200 per jar). The daphnia should be large with many individuals approaching 1/8 inch in length.

Shipment G

100 mature aphids

Shipment H

80 small to medium size crickets
7 large chameleons

GRADE THREE (continued)

Shipment I

1 pint established Chlamydonomas algae culture (or other single-celled algae, filamentous algae not acceptable)
16 damselfly or dragonfly larvae
18 pond snails (Physa or Lymna)
1 jar Daphnia magna culture (200 per jar). The daphnia should be large with many individuals approaching 1/8 inch in length.
1 jar Wolffia
1 package Hornwort (17 sprigs)

KINDERGARTEN

Shipment J

4 freshwater fiddler crabs
4 goldfish
4 newts and newt food
6 pond snails
4 sprigs Hornwort
1 jar of duckweed
4 dwarf lily bulbs
1 container of fish food

GRADE FOUR

Protozoa: Ameba, Paramecium, Euglena (50 ea)
32 Crayfish

GRADE SIX

100 Mealworm Larvae
1 lb. Bran

## KIT RESUPPLY

Classroom teachers have two options for resupplying the science kits.

**Option A:**

(Grades 1, 2, 3).
Request your school secretary to arrange for the Science Materials Attendant to come into your classroom one day each year to refurbish the kit (cart).

(Grades 4, 5, 6)
Send the kit into the warehouse for refurbishing. Allow a two-week turnaround time. This can be done after each use on a quarterly basis.

**Option B:**

(All Levels)
Write the name and number of the items needed on a sheet of paper and send it to the Science Materials Attendant at the warehouse. NOTE: It is better not to send the entire kit in if only a few items are needed, especially the LEGO and Voyage of Mimi kit.

The items used at each grade level and the warehouse location of most items are included on the following pages to assist you in this option.

## TIME ALLOTMENTS FOR ELEMENTARY SCHOOL SCIENCE

### Kindergarten

The activities suggested for kindergarten classes indicate that 45 to 50 minutes per week devoted to science would be sufficient to cover the materials. Because readiness programs contain outcomes common to many disciplines, teachers can and should teach these science lessons within an interdisciplinary context.

### Grade Levels 1-3

At the primary grade levels (1-3), a total of 100 minutes per week is to be allocated for science instruction. This time allocation is for budgeting purposes and teacher discretion is necessary when planning the lessons. For example, three 33-minute periods per week may be more efficient and productive for quality learning to occur than five shorter periods.

### Grade Levels 4-6

At the intermediate grade levels (4-6), 200 minutes per week (40 minutes per day) becomes available for the teaching of science. Teacher judgment and experience indicates that fewer, but longer time blocks allow for preparation, active participation, and clean-up in a productive and efficient manner.

## SCIENCE FOR THE EXCEPTIONAL CHILD - MAINSTREAMING CONCERNS

Every effort is being made to assist teachers in the elementary school science classroom with mainstreaming pupils who are handicapped and/or gifted/talented. Portions of the basic elementary school science program have been modified, alternative units developed, and certain activities selected for their modifiability, their multisensory approach to instruction, or potential for challenge to accommodate the special needs of a specific child or group of children. These alternatives are intended to allow pupils to participate at their instructional level, within the lessons/units of the prescribed program. Efforts in this area will continue and are in addition to the various pullout options. Call the district science consultant for assistance in securing the materials, implementing the modifications, and/or developing other suitable alternatives.

## THE SCIENCE FAIR

The key concepts, variety of activities, individualized instruction, and independent experimentation in our science curriculum inject many opportunities for children to go beyond a particularly interesting activity and pursue it as a personal investigation suitable for the science fair. As the teacher of the science participant, your role of guide and catalyst is very important for the pupil to have a successful experience. Although district science fair participation is limited to the intermediate grades, primary classrooms can encourage the inquisitive, creative child through the nature of the things displayed from time to time. Children will find our curriculum very supportive and helpful in preparing them for science fair participation. However, you as a science teacher are vital in assisting these children as they pursue a project.

To assist you in this endeavor, a folder has been developed and is available from your building science fair representative. It contains many ideas for identifying and developing a quality science fair project and is highly recommended for your perusal. It can be used as a checklist and guide in helping the prospective science fair participant complete his/her project.

## SAFETY IN THE ELEMENTARY SCHOOL SCIENCE CLASSROOM

The health and well being of the child should be a major concern for all teachers and staff members at all schools. Certain activities tend to provide more opportunities for physical injury than others. Some activities from science fall into this category.

The safety of the child in using the materials provided and in doing the activities suggested was a concern of the Science and Related Fields Committee. The units selected and developed were judged to be suitable and safe for the intended children. However, good judgment and proper supervision on the part of the teacher is still important. The following safety related document provided by the Minnesota Department of Education and reprinted with permission of the Virginia Department of Education is offered for your perusal and reference.

Minnesota Department of Education

# Science Safety K-6

## SAFETY GUIDELINES FOR ELEMENTARY SCIENCE

(Used with Permission from Virginia Department of Education)

The success of an activity-centered elementary science program is contingent upon many factors, including adequate planning. In addiiton to general planning to meet the needs and interests of pupils, specific plans must be made for safety in all activities. Unfamiliar activities should be performed by the teacher before they are introduced to children. This will allow the teacher to:

- know what to expect
- estimate the time needed for the activity
- anticipate the children's questions
- check equipment and materials
- acquire needed quantity of equipment and materials
- modify procedures to suit children's abilities
- become cognizant of safety considerations

### GENERAL SAFETY CONSIDERATIONS

1. Procedures and safety considerations must be reviewed with children before beginning any activity. Safety apparatus equipment should be demonstrated and its use explained verbally. Posting of regulations is also recommended.

2. Sufficient time should be allotted for children to perform assigned activities.

3. When groups of children are working with limited equipment, the group should be small enough to prevent accidents.

4. When using equipment and materials that might be hazardous, small groups should work under constant supervision.

5. Equipment should be moved through hallways when they are not crowded, in suitable containers, or on equipment carts, to avoid breakage.

6. Use of equipment such as saws and knives may require special instructions.

7. Equipment should be inspected for flaws, defects should be repaired or the equipment should be replaced.

8. Student materials should be stored in easily accessible locations. Heavy equipment should be stored on lower shelves.

9. All accidents should be reported to school authorities according to procedures established by the school. Teachers should be familiar with local procedures.

10. Fire apparatus, $CO_2$ estinguishers and fire blankets, must be available for use if needed when an activity requires the use of a heat source.

### SAFETY WITH HEAT AND ELECTRICITY

1. Any piece of equipment (including a projector) which is hot should not be moved until cool.

2. Hot plates with smooth surfaces, rather than coils, are preferable to other types of heating equipment.

3. All heat sources should be observed carefully until cool.

4. Substances being heated should be on a firm support to prevent spills.

5. If open flame heating devices (candles, propane or Bunsen burners, or alcohol lamps) are used, caution is needed regarding loose clothing and long hair should be tied back.

6. Alcohol must not be heated over an open flame. The use of a water bath is recommended and then only as a teacher demonstration.

7. Provisions must be made to handle exhaust fumes, including those produced by heating of alcohol.

**SPECIAL NOTE ON ALCOHOL BURNERS:**

The use of alcohol lamps (burners) should not be permitted unless no other heat source is available or adequate. When this form of heat is used, the following steps must be observed:

a. A teacher must be present in the classroom at all times whenever alcohol burners are in use or being refueled.

b. The refueling of burners in any classroom must take place in a well-ventilated location when there is no open flame. The location must be selected to be away from exits to the room and far from other student activities as feasible.

c. Large stock containers (liter or larger) of alcohol should not be allowed in the classroom. Under teacher supervision, small containers can be used by students at the refueling station. These containers must be kept capped at all times and opened for each refueling operation. Small containers must be filled by the teacher at a time when the class is not in session.

d. Lighted burners should not be carried from place to place in the classroom. Before a burner is carried the flame must be extinguished and the wick cover put in place.

e. Wick covers must be placed on burners after they are extinguished.

f. An extra set of alcohol burners must be available at the refueling station so students will not have to refuel hot burners. Whenever possible, an attempt should be made to fill extra burners prior to the beginning of the class period.

g. Since alcohol expands when heated, burners must not be filled to the brim.

h. Recurring inspections are required to assure that all burners are in proper operating condition. Malfunctioning burners are to be discarded.

i. During laboratory sessions requiring alcohol burners, fire extinguishers and fire blankets must be in the classroom.

j. All alcohol burners are to be in locked storage area when not in use, and care must be taken to assure that they will not be accessible to unsupervised students.

k. Protective eye devices should be worn by all students whenever lighted alcohol burners are used in the classroom.

## SAFETY WITH PLANTS AND ANIMALS

Because children are curious by nature they are intrigued by living things. The use of live animals in elementary classrooms can provide learning experiences that are both pleasant and instructive.

1. Teachers should select those animals that suit their instructional needs and are practical to maintain, given the conditions of the school. It is not the number of animals in the classroom that is important, but the educational use that is made of them.

2. Any mammal kept in the classroom should be free from disease and should be from a domestic source such as a qualified animal distributor or pet shop.

3. Innoculation against rabies is required by state law for all large domestic mammals (such as dogs or cats) at six months of age. Smaller mammals, such as mice, guinea pigs, rabbits, hamsters, and gerbils, are good choices for classroom use and need not be innoculated against rabies. A local veterinarian should be consulted concerning species of mammals that require rabies innoculations.

4. Some birds, such as chickens, are suitable for classroom study, particularly in relation to the incubation and hatching of eggs. Other small vertebrates, such as fish, frogs, salamanders, lizards, and box turtles also can be maintained in the classroom. Invertebrate animals such as earthworms, sow bugs, ants, mealworms, caterpillars, crayfish, hermit crabs, and snails are other good choices for classroom study.

5. When preparing for the introduction of live animals or plants in the classroom, the following suggestions should be kept in mind:

   a. Bats should not be kept or handled, because they may carry rabies.

   b. Ducks, parrots, and parakeets may be carriers of human respiratory diseases and are not recommended for school use.

   c. Red-eared turtles (sometimes sold in pet shops as "painted turtles") may be carriers of salmonella and should be avoided.

   d. Raccoons and skunks are not suitable for school use, as they may inflict severe bites.

   e. Certain species of animals are protected by federal and state law and should not be kept in captivity. The current list of such protected species can be obtained from a game warden.

   f. Use of poisonous animals should be prohibited.

g. Plans should be made to feed and house an animal before it is brought into the classroom.

h. Animals should be handled only when necessary. Wearing of heavy gloves is recommended . . . for safety.

i. Children should wash their hands after handling animals.

j. Cleaning of animal containers should be done regularly and waste should be disposed of properly.

k. All animal bites should be reported to the principal and a local medical authority consulted.

l. Before diet deficiency experiments are undertaken, the local or state science supervisor should be consulted.

m. Plants that might cause allergic reactions should not be used in the classroom.

n. Bacteria and molds should not be cultured.

o. Dissection of animals is not recommended.

## SAFETY WITH CHEMICALS

1. Containers should be properly labeled.

2. Random mixing of chemicals should be prohibited.

3. Volatile or flammable liquids must be used with caution near heat sources.

4. Dangerous chemicals should be used only under teacher supervision. Teachers are cautioned against assigning homework or independent study that involves the use of hazardous chemicals when supervision is not available.

5. Emphasis must be given to the fact that use of chemicals requires that directions for an activity are to be followed precisely.

## EYE PROTECTION

1. Any activity in which there is danger to the eyes should be performed while wearing protective eye devices. Such activities include:

   a. heating substances

   b. chipping rocks

   c. using caustic or corrosive materials

   d. when lighted alcohol lamps are in use

   e. mixing substances

2. Solar Eclipse

   a. At no time should a student be instructed to look directly at the sun, even during an eclipse. Severe eye damage can be caused by the intense sun rays; smoked glass, dark glass, sun glasses, or developed exposed film are not recommended as shields for solar viewing.

   b. Indirect viewing is the only method recommended. This can be accomplished by projecting the sun's image through a small hole in a piece of cardboard onto a piece of white paper. With this arrangement, the student's back should be towards the sun.

## EXPERIMENTS CONDUCTED AT HOME

1. Teachers assigning children activities or experiments to be conducted outside the classroom shall discuss the activities with their principal prior to making the assignment. Safety precautions shall be discussed with the students and transmitted to the parents prior to assigning the activity.

2. Children should be encouraged to discuss with parents all self-initiated experiments conducted outside of school.

## OUTDOOR ACTIVITIES

Outdoor environment study activities are an important part of the science curriculum. However, the following precautions should be observed:

1. Teachers should check student medical records and consult parents for information about allergies prior to taking children into outdoor study areas.

2. The handling of wild animals is not recommended unless supervised by an expert.

3. Many plants are poisonous. Wild plants, roots, or berries should not be eaten.

4. Teachers should visit the site of a proposed field trip before the children are taken to it.

## REFERENCES

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**INSTRUCTIONAL STRATEGIES**

A. Science Education: The Unfolding of Thinking

One of the most familiar metaphors in science education is the teacher-student- subject triangle. (of. David Hawkins, the ess reader. 1970, pp. 45-51). This is familiar true to science teachers; it is the classroom. While the overall emphasis of this document which contains guidelines for local decision making is on the subject corner of the triangle, so much so that the triangle is greatly truncated, we are very much aware that it is in the relationships between the three that science education is ultimately won or lost. We recognize, too, that this triangle is embedded in a much larger social, cultural, and economic context.

The focus of this short section is on another corner of the triangle: the student. It is about how this corner, namely the thinking abilities of children, affects the relations between the other two corners.

> Compared to other living organisms that we know about, humans enter this world quite emptyheaded. Many species of birds, fish, and other animals are preprogrammed with information that enables them to survive, gather food, and reproduce their own kind. Some can travel to locations they never experienced directly. Others behave in ways that are independent of learning. But the human baby is quite helpless. It must *construct* a view of the world itself.
>
> Lawrence F. Lowry
> in Developing Minds, Association for
> Supervision and Curriculum Development
> 1985, pp. 72-80 (emphasis added)

How we think and learn to think is not something we often think about. Our view is that knowledge is personally constructed; the myth is that it is discovered (and some of it may be) and then transmitted to learners.

The sequential development of thinking capabilities and the idea that we construct knowledge is supported by a novel and diverse research base. Science educators are probably most familiar with the work of cognitive psychologists. These include Jean Piaget, Jerome Bruner, Robert Gagne, and Erik Erickson. Two other cognitive psychologists deserve mention. The research of Joseph Novak and David Ausubel, who, while repudiating the Piagetian notion of stages of cognitive development, also provides convincing evidence that we construct what we come to know.

The neuroscience research base about the nature of human thinking is less well known to most science educators. This work is *briefly* summarized by Lawrence Lowery (of. Developing Minds, Association for Supervision and Curriculum Development, 1985). It includes growth spurts of the brain, patterns of cellular growth, and electrical activity. Neuron development and myelination of the brain progress in stages. It takes about eleven years for the myelination of the corpus callosum which results in regular communication between both sides of the brain. All of this is not to say that the answers are in. Much more research is necessary to determine the relationship of learning tasks and the timing of their presentation to the development of cognitive abilities.

B. Piagetian Education

The discussion that follows is based on the work of the Swiss psychologist Jean Piaget (1896-1980). It is often referred to in the science education literature. The overall goal of Piaget's research was to develop a general theory of knowledge. The approach he took was developmental—how and why does knowledge of a thing develop as it does? How do individuals come to know what they know? How does the ability to reason mature over time? Piaget's research was based on naturalistic observations, interviews, and the involvement of children in tasks.

In seeking explanations for the development of children's cognitive abilities, Piaget identified four major cognitive developmental stages of reasoning that are spaced and occur in intervals. These stages are: 1) sensorimotor—information is organized into mental structures by sensory experiences; 2) preoperational—thinking is centered on self and is often intuitive; 3) concrete—meaning is primarily in physical terms; and 4) formal though — thinking in terms of the possible or hypothetical these stages respectively: 1) the active child; 2) the intuitive student; 3) the practical student; and 4) the reflective student.

While it has been well documented that children pass through these stages in the same order, including across cultures, it is important to understand that the rate varies between individuals and that the developmental stages are not age determined (the stages are statistical averages). Piaget did not view the stages as a series of limitations although they are often described in this way. Joseph Pearce puts the development of thinking this way:

> Although at any stage of development nature is preparing us for the next stage, the beauty of the system is that we are conscious of none of this. Ideally, we must fully accept and exist within our developmental stage and respond fully to its content and possibilities. This means that every stage is complete and perfect within itself. The three-year-old is not an incomplete five-year-old; the child is not an incomplete adult. Never are we simply on our way; always we have arrived. Everything is preparatory to something else that is in formation.
>
> The Magical Child
> E.P. Dutton, 1977

Each stage represents both new thinking capabilities and also a new period for integration and consolidation of cognitive content. In each stage, experience, information, and knowledge are uniquely organized into a different view of the world. In the sensorimotor period, it is a highly sensory world view; in the period of formal thought, it is the ability to identify and isolate the possible combinations of variables (and establish their relationships) involved in complex problems.

Characteristics of each of the four Piagetian stages are summarized in the following table. What is not clear in the table is that the characteristics have a beginning and an ending. In the sensorimotor period, for example, the child begins with no concept of space and ends up with a concept of immediate space. Furthermore, the development of reasoning is both richer and a more differentiated process than is shown here. Interested readers should refer to the literature, e.g., *Piaget for Educators* by Rodger W. Bybee and Robert B. Sund (Merrill, 1982).

In many discussions of the significance of Piaget's work for science education, cognitive stage theory—ages and stages—is regarded as the most distinctive feature. This is a very limiting interpretation of Piaget's overall framework and of children. Most children are in transition and demonstrate varied reasoning patterns. This is perhaps most noticeable in the state between concrete operational and formal thought, i.e., in students in upper elementary, middle, and junior and senior high school. During this period, students use concrete operational thought consistently; formal thought inconsistently.

Piaget did not view the stages of thinking development as his most important contribution to a theory of knowledge development. What we should learn from Piaget is that learning and reasoning are active processes. In other words, humans construct what they know. They do this by modifying ideas, not simply by receiving new ones. A person's current construction of experience is the basis for processing new information and for organizing it into new mental structures. For science educators, this means that children come to school with neither blank minds to be filled *by* school science experiences nor that they are without strong theoretical views about how the world works. That they bring sundry ideas to science, often in the form of misconceptions, is well known to science educators.

Selected examples of such pre/misconceptions or, more broadly speaking, "alternative frameworks," include:

1. Elementary School—I can see because light shines on things and brightens them or food for plants is whatever material is needed and taken in by the plants or the attribution of life to inanimate objects (About rain: "Clouds think it's too hot...I guess they start sweating and then the sweat falls on us.")

2. Middle/Junior High School—Water tables are underground lakes or the shadow of the earth causes the phases of the moon or a large ice cube takes longer to melt than a small ice cube because the large ice cube has a colder temperature than the small ice cube.

3. Senior High School—Heavier objects fall faster than lighter objects dropped from a moving carrier will fall straight down or plant food should have a place in a food chain or all mutations are harmful to the organism.

Table

As Thinking Unfolds, Understanding Develops

| Stage | Approximate Age Range | Approximate Grade Level | Thinking Characteristics |
|---|---|---|---|
| SENSORIMOTOR (ACTIVE CHILD) | 0-2 | Preschool | Interacts through sensory and motoric activities<br>Developing concept of self, space, time, cause/effect, play and object permanence (objects exist even when out of sight)<br>Actions imposed on objects one at a time |
| PREOPERATIONAL (INTUITIVE STUDENT) | 2-7 | Preschool 2 | Intuitive answers ("Because")<br>Egocentric (child center of reality)<br>Aware of past, present, and future<br>Make believe play<br>Animistic explanations of cause/effect<br>Reasons in one direction (A causes B, B causes A)<br>Groups two objects (attribute)<br>Links two events (relationship)<br>Can imitate actions |
| CONCRETE OPERATIONAL (PRACTICAL STUDENT) | 7-11 | 3-6 | Restricted to direct experience (requires objects)<br>Classifying/Grouping with a rational logic<br>Reversing though processes (A B, B A)<br>Mathematical operations<br>Combine more than one idea at a time<br>Unaware of inconsistencies and mistakes in reasoning<br>Clear, sequential directions for projects |
| IN TRANSITION (IN-BETWEEN STUDENT) | 11-15 | Middle/Jr. High School | Rational but unsystematic approach to problem solving<br>Uses concrete procedures to solve abstract problems<br>Inadequate observations and procedures used for difficult problems |

Table–As Thinking Unfolds, Understanding Develops (Cont.)

| Stage | Approximate Age Range | Approximate Grade Level | Thinking Characteristics |
|---|---|---|---|
| FORMAL OPERATIONAL (REFLECTIVE STUDENT) | 14–Adulthood | Senior High School | Abstract reasoning<br>Hypothetical-deductive reasoning (can manipulate and control variables)<br>Proportional reasoning<br>Combinatorial reasoning (organize and reorganize) |

Facilitating Cognitive Development: Where Do We Go From Here?

> It is important for curriculum and instruction to reflect the biological basis for thinking. A horizontal curriculum is one in which students are challenged to use a particular stage of thinking with different materials at various levels of abstraction without the progressive requirement of having to be at a more and more advanced developmental stage. The model allows students at an identified stage of development to explore many experiences within and near that stage... The essence of the approach is derived from the biological basis for thinking — the thinking capability is independent of the objects involved in a given task. Students experience small, sequential steps of equilibration through an inexhaustible set of possible experiences.
>
> Lawrence F. Lowery
> p. 77 in Developing Minds
> Association for Supervision
> and Curriculum Development
> 1985

What interested Piaget throughout his life was the relationship between thinking and things. While his work has shown us many things, one of Piaget's most significant findings may be that the way children organize knowledge throughout life and the way adults organize knowledge is different; not wrong, but different.

While Piaget's writings are voluminous, he wrote only two books, relatively late in his career, about education. Specific suggestions for instruction in science based on Piaget's theory were first developed by Robert Karplus and his colleagues at Lawrence Hall of Science, University of California, in the 1960s. This application of Piaget's ideas for science educators is known as the teaching/learning cycle. The design is the basis for the elementary school science materials developed for the Science Curriculum Improvement Study (SCIS). The teaching/learning scheme is divided into three stages: **CONCEPT EXPLORATION, CONCEPT EXPLANATION,** and **CONCEPT EXTENSION:** Robert Karplus called these stages, respectively, exploration, invention, and discovery.

Piaget has stated, "There is no learning without experience." This is the basis of the teaching/learning cycle. the emphasis in activities using the teaching/learning cycle is an experience...in helping learners create their own knowledge of and about a particular idea.

*Concept Exploration*

In exploration activities, minimal directions are given by the teacher. This is a period of gathering data usually using the materials of the discipline.

In elementary school, children would be encouraged to discuss what they observe and to ask questions about preselected science materials. An example is introducing a unit on sound, e.g., whistles. Plastic tubes of different length and caps to cover their ends would be provided to students and they would be asked: "What can you find out about the sounds made by these tubes?" In high school, the activity might be a laboratory experiment or field trip that produces observable data. However, these are not the only possibilities for exploration experiences. Films, discussions, demonstrations, thought puzzles, etc., can be used as effectively. The criteria for an exploration activity include active engagement, an appropriate level of puzzlement (i.e., the student is not bored with the activity or paralyzed by it), and an active search for an explanation on the part of the student. Students may observe patterns, identify variables, or attempt to answer questions.

*Concept Explanation*

This is a period of organization in which students look for patterns and seek to make sense of the data collected. The teacher introduces the appropriate concept or sometimes concepts for what is occurring. The concept explanation part of the cycle is teacher directed. It is often in the form of a teacher led explanation. However, diagrams, tables, graphs, pictures, films, and even additional activities are also used equally effectively. The purpose of the concept is to help students explain and understand their experience in a simple, clear, and direct manner.

*Concept Extension*

In this phase of the learning cycle, the already introduced and partially (to fully) developed concept is used to apply, expand, modify, limit, or broaden the concept. This is a period of consolidation, providing both time and experience(s) for this to occur. The set of possible experiences is somewhat inexhaustible. The use of multiple activities are very similar to concept exploration activities. They can include the same diverse array of activities: hands-on, active laboratory investigations; reading; problem sets; puzzles; and so on.

*The 4th E, Concept Evaluation*

As they learn, students need to know how well they are learning and understanding concepts. Teachers also want to know how well students are doing. Such information is useful to teachers in assessing instruction and in evaluating appropriateness of concepts and designing experiences to help students learn them.

Evaluation is very much a part of the learning cycle. However, it must go beyond standardized achievement tests that are based almost exclusively on course content and often consist of a multiple-choice format consisting mostly of recall items. After labeling the concept "insect, ...the learning sequence would be completed by having students respond to:

According to this information, what are some of the characteristics of these invertebrates that make them like insects? What was true of the insects that is not true of any of these other insect-like animals is _____.

Based on what you've said here, finish the statement "What makes insects different from other insect-like animals is _____."

Identify the animals shown here which you think are insects and the ones you think are not. For each, be ready to tell what about the animal made you decide it was or was not an insect." (Sydelle Steiger-Ehrenberg, "Concept Learning: How to Make it Happen in the Classroom," Educational Leadership, October:36-43, 1981)

Evaluation must reflect the full range of learning experiences a student has in a science course, too. Can students read information from graphs and tables; express information in graphs and tables; use measuring instruments and other scientific equipment; estimate quantities; observe similarities and differences; interpret diagrammatic, tabular, or written information; use scientific symbols, etc.? What this means is that some of the evaluation used in science must include practical items, e.g., measuring or using scientific equipment, as well as written items.

Attitudes are, of course, extremely difficult to assess. However, few deny the importance of assessing attitudes and attitudes toward science. Some of these can be assessed by simple paper and pencil tests; others will be based on teacher observations and discussions with students.

The teaching/learning cycle is summarized in the following table.

The Teaching/Learning Cycle*

---

Concept Exploration

Students learn through their own activities.
Learning is "directed" by the objects, events, or situations.
Teacher guidance is minimal.
Activities should leave students with unanswered questions.

Concept Explanation

A concept or principle is presented.
The concept should be related to the exploration activity.
Different instructional materials and approaches can be used.
Instruction is teacher directed. Instruction should help students answer their questions.

Concept Extension

Students are given different activities in which they must apply new concepts and reasoning patterns.
Additional time and experiences are used to extend student understanding.
Different instructional approaches can be used during this phase.

Concept Evaluation

Student learning is evaluated in a variety of ways.
Feedback is used by the teacher to recycle students through appropriate teaching/learning phases.

---

*Figure 9.1, p. 210, from *Piaget for Educators*, Second Edition, by Rodger W. Bybee and Robert B. Sund, 1982. Charles E. Merrill Publishing Company, Columbus.

The teaching/learning cycle is an activity-oriented approach to learning science. In many respects, its central purpose is to help students develop the ability to think autonomously. It is designed to help students make decisions for themselves. In such an approach, science includes not only traditional science content but also a variety of scientific process skills and attitudes. It suggests, too, that these parts of thinking interact, e.g., when one makes observations they are not independent of experience, we learn what is relevant to observe, etc.

Piaget's work shows us that instruction should be based on an understanding of the developmental process. All children pass through four main stages of cognitive development. The curriculum design must be appropriate to this developmental process. Students construct what they know as a result of both mental *and* physical activity on what is being investigated. Science lends itself well to this because this action on things — mental and physical action on things. Students should have extensive experience with objects as they learn.

## Implications of Piaget's Theory for Elementary Students

The science of elementary school is *not* specific preparation for the junior and senior high school science to follow. The idea of treating specific topics should not be one of a "science readiness" for secondary school. Elementary school is a place to gather and widen a child's experience. In *What Research Says to the Science Teacher* (1981, NSTA), members of an elementary school focus group wrote that the study of science "is the place to excite students' curiosity, build their interest in their world and themselves, and provide them with opportunities by introducing exciting and important phenomena to be observed and analyzed, but it should not reflect a need to cover a syllabus of content in all science disciplines."

Elementary school science should broadly sample the major content areas of science. There should be some balance between the physical sciences and the life sciences. Children should not be stuffed with words or asked to consider concepts too abstract to be well understood. Most of all, concepts should not be selected just because they are "in the book."

Finally, the curriculum should facilitate development of the intellect. This requires action-oriented science activities — "hands-on and brains-on." The teaching/learning cycle of concept explanation, concept extension, and concept evaluation can be used to facilitate active inquiry, decision making, thinking, and learning the content and processes of science.

## Implications of Piaget's Theory for Secondary Students

There is considerable evidence that the progress from concrete to formal though processes does not automatically happen at the end of elementary school, i.e., with the biological changes of puberty. But science at both the junior and senior high school level is characterized by formal concepts. "The safest estimate," according to Rodger W. Bybee and Robert B. Sund (*Piaget for Educators*, Charles E. Merrill, 1982) "is probably about 25 percent of students will display formal thinking during secondary school years." This means that the majority of junior and senior high school students still need physical, hands-on experience as they reason and grow in their ability to think about science.

Like elementary students learning science, secondary students are likely too, to learn science best by *first* experiencing a concept or phenomena of science through the materials of the discipline (earth science, physical science, biology, chemistry, physics), *then* to label the new idea through the introduction of appropriate language and *finally,* to expand the new idea by applying, modifying, limiting, or broadening it. Experience...Language...New Experience(s). The science education cycle begins at the concrete and progresses toward the abstract.

This cycle of learning implies a variety of learning modes and strategies. However, laboratory work becomes imperative, because it is a common, concrete experience. In the Science Teacher (May 1983), Jerry E. Ivins, a teacher in Cincinnati, described five different kinds of laboratory experiences. Each laboratory experience has a legitimate place in high school science and each is summarized in the chart on the following page.

One of the special difficulties of secondary school is content. However, many of the concepts students encounter require the development and use of formal operational thought. This section is a plea for the facilitation of cognitive development. The basis for that, even in secondary school, is still "action on things" using concrete experiences. Reasoning is not memorizing. Your methods should actively involve students. You can help students by your awareness that most of them are either at the concrete level or in transition to the formal level of thinking. Use questions during laboratory work to engage them, too. "How did you get your answer?" "What are some sources of error in your work?" "How could you improve the experiment next time?" "What if you did...?"

Today, in spite of the imperative of textbook size, everything cannot nor should not be "covered." The emphasis in this document, as biologist John Moore reminds us, is "on the ubiquitous and important and not the rare and important or ubiquitous and unimportant." A science education curriculum that focuses on the science technology that is essential for students to know, that helps them know why they know, that supports the students' learning of skills, and that leads them somewhere that is important, useful, interesting, and is personally connected to the world of the learner, is a powerful receipe for change. It is a case where less is, indeed, more.

## The SCIENCE LAB in Learning

| Type | Purpose | Characteristics | Teacher Actions |
|---|---|---|---|
| A | 1. To develop background information and experiences<br>2. To recall prior knowledge<br>3. To create readiness for new learning | . Exploratory in nature<br>. Minimum structure but with definite purpose<br>. Materials carefully selected | . Select focus and materials<br>. Observe student student interactions<br>. Minimum instructions<br>. Use the experience to teach the next concept |
| B | 1. To develop a skill/procedure<br>2. To practice a skill/procedure | . Does not require formal reasoning<br>. Establishes processes used (i.e., observing) | . Teach and model the skill |
| C | 1. To clarify<br>2. To make an idea real (concrete)<br>3. To verify<br>4. To conceptualize an abstraction | . Procedural, sequential steps<br>. Focused actions<br>. Predetermined outcomes and expectations<br>. Results comparable between groups | . Carefully planned structure<br>. Communicate what, why, and how<br>. Foster closure: relate results to the purpose |
| D | 1. To apply to new concrete situations<br>2. To promote further thinking: reflective and creative<br>3. To test reality | . Focused initial charge<br>. Student designed procedures and data handling<br>. Variety in materials and products | . Provide instructions (charge & purpose)<br>. Develop ways to handle data<br>. Lead discussion<br>. Foster closure related to the common starting point<br>. Promote divergent ideas |
| E | 1. To investigate an area of interest<br>2. To search for answers to specific questions<br>3. To practice scientific procedures | . Student selects problem area<br>. Student phrases the question/formulate the problem<br>. Student designs and conducts experiment<br>. Student records and communicates data and conclusions | . Coach: Encourage and support<br>. Guide: suggest, remove barriers, critique process and results<br>. Be an interested audience |

## SCIENCE INSTRUCTION INVOLVING THE LABORATORY

**USING LABS**
(Some teacher actions)

I. Think Ahead:

- A. Determine Purpose of (such as to)
  - 1. Develop prior knowledge/skills
  - 2. Make concrete/demonstrate
  - 3. Verify/test
  - 4. Investigate/inquire
- B. Secure Equipment

II. Think While:

- A. Monitor and Coach
  - 1. Listen to conversations
  - 2. Discuss with students
  - 3. Question students
  - 4. Suggest next steps
  - 5. Suggest data recording methods
  - 6. Suggest information resources
- B. Check for Safe Procedures

III. Think After:

- A. Bring Closure of
  - 1. Organize data
  - 2. Analyze results
- B. Find Meaning
  - 1. Develop connections/conceptions
  - 2. Identify and correct misconceptions
  - 3. Suggest further information resources
  - 4. Suggest next level inquiries

**DOING LABS**
(Some learner actions)

Think Ahead

- What am I trying to find out?
- How will I proceed?
- What should I do first?
- What materials will I need?
- What safety precautions should I be aware of?

Think While

- What should I do next?
- What do I observe?
- What data should I record?
- How should I record data?
- What happens if...?
- Am I being safe?

Think After

- What surprises did I experience?
- What new information did I acquire?
- What problems did I encounter?
- What does it all mean?
- What new questions do I have?
- How can I organize the data so it makes sense to me?
- How can I communicate this to others?

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LESSON 3

CONCEPT: Our Senses Help Us Learn About The World

TITLE: Sound

OBJECTIVE: At the end of this lesson the pupils will be able to use the sense of sound to describe objects in our world.

TIME: 30-40 minutes

MATERIALS: Sound tape, Senses Chart, Master #2B.

VOCABULARY: Inference, sound.

DESIGNING A LESSON:

1. Have the pupils close their eyes and listen carefully. Ask:

   **What sounds do you hear in the silent classroom?**

   **What sounds came from inside the classroom?**

   **What sounds came from outside of the classroom?**

Note: By asking pupils to associate sounds with particular feelings or actions, you are developing the ability to make inferences.

2. Have one child close the door and ask the children to describe the sound it makes. Let the children imagine all the different ways a door could close, e.g., slamming, creaking, etc.

   **What can the way the door is closed or opened tell us?**

   Have children experiment with closing and opening the door in different ways. Do the same thing with footsteps. Have the children take turns walking across the front of the room while others close their eyes.

   **Are the steps fast or slow?**

   **Heavy or light?**

   **Angry or happy?, etc.**

   **When would you hear this sound?**

3. Play the sound record or tape. There are three parts to the tape:

   Part 1 - Sounds all around (awareness);

   Part 2 - Have the children identify the sounds heard;

Part 3 - Divide the children into small groups and have them practice making sounds themselves. Sample sounds are ticking, clapping, windy, whistling, stopping, rubbing, scratching, or clicking.

CLOSURE: Check off the sound column on the Senses Chart.

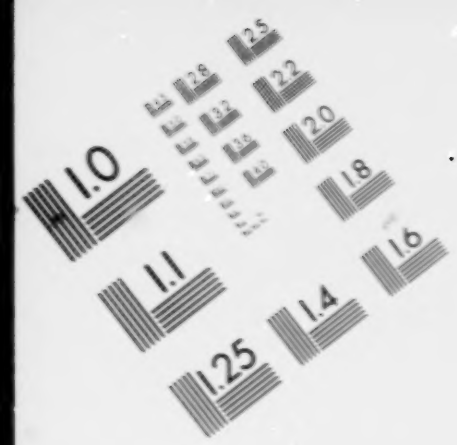
EVALUATION: Point to the sense you used in our lesson today.

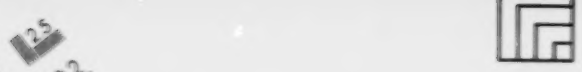
OPTIONAL ACTIVITIES:

A. Tape, write, or draw a sound story from the tape.

B. Go on a sound walk. (List the sounds children have heard on the walk.

C. Tape record the sounds on the walk.

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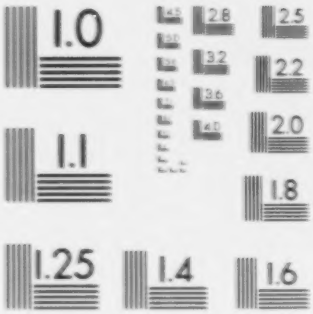

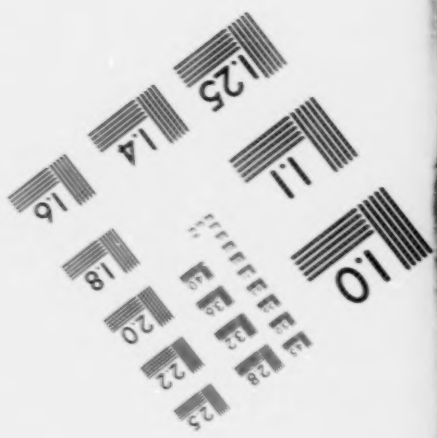


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LESSON 8

CONCEPT: Properties

TITLE: Color and Size

OBJECTIVE: At the end of this lesson the pupils will be able to:

1. observe and describe buttons,
2. sort by color and size properties.

TIME: 30-40 minutes

MATERIALS: Buttons, Property Chart.

VOCABULARY: Sort

DESIGNING A LESSON:

1. Ask:

   **Who can tell me the properties of Toad's button from the story, A Lost Button?** (white, two holes, round, thick, and big)

2. Give each child a set of buttons (at least 8 to 10).

3. Ask the children to find a button like Toad's button, that has at least three properties.

4. Ask the children to sort their button by color. Have children describe their sets, for example, light/dark, red/blue, etc.

5. Repeat step 4 using size as a property to sort with.

CLOSURE: List size and color property words on Property Word Chart, Master #7B.

EVALUATION: Teacher observes pupils ability to describe buttons by properties.

OPTIONAL ACTIVITIES:

A. List all of the things your class can think of that are red or large, etc.

B. Mix and Match activity from mathematics program.

LESSON 9

CONCEPT: Properties

TITLE: Shape

OBJECTIVE: At the end of this lesson the pupils will be able to solve simple tangram puzzle problems.

TIME: 30 minutes

MATERIALS: Tangram pattern (pupil copies), a transparency of Master #9A.

VOCABULARY: Tangram, triangle, square, rhombus.

DESIGNING A LESSON: Tell the pupils this story: *According to an ancient legend, a Chinese scholar had a favorite ceramic tile that he considered his greatest art treasure. One day he was walking with it in his hands when he tripped. The tile fell from his hands and smashed into seven pieces on the stone floor. The scholar spent the rest of his life trying to put the tiles back together again.*

*Today we are going to help the scholar put the pieces together.*

1. Distribute the puzzle pattern sheet.
2. Have the pupils cut out the pieces carefully.
3. Tell the pupils to scramble the pieces and then put the puzzles back together.
4. After a short period of time, display the pattern on overhead to help those who need it.
5. Describe the pattern shapes.

CLOSURE: Add shape words to the Property Word Charts, Master #7B.

EVALUATION: Check to see if pupils can put the tangram together.

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## Lesson 4 - A Controlled Experiment

NOTES

### GOAL/RATIONALE

The purpose of this lesson is to explore the concept of a controlled experiment.

### ANTICIPATORY SET

*Yesterday I wound the propeller * times and it flew half way down the flight line. This morning I tried the same experiment and I changed two variables. I changed the slope of the flight line and I made the room dark.*

*The plane flew farther than it did yesterday. So, my conclusion is, that by making the room dark and by having a downward slope of the flight line, a plane will fly farther.*

**Who agrees with my conclusion? Why?** (There are no right or wrong answers.)

*The number of winds you use here should be the same as the number of winds you agreed upon in Lesson 2 Closure.

### OBJECTIVES

At the end of this lesson the pupils will be able to:

1. Define what constitutes a controlled experiment.
2. Conduct a controlled experiment.

### DIRECT INSTRUCTION

Materials Needed: See Lesson 1

Write this definition on the board.

*A **controlled experiment** takes place when all variables except one are kept constant.*

1. ***Was my experiment a controlled experiment? Why or why not?*** *(My experiment as described was not controlled because two variables were changed; slope and darkness.)*
2. ***Is my conclusion right or wrong?*** *(Wrong, because either variable could have caused the plane to fly farther by itself.)*
3. ***How can we change my experiment to make it a controlled one?*** *(See below.)*

*When all variables are kept constant except the slope of the flight line, you would have a controlled experiment. If a change in a flight distance occurred, it could be attributed to the only variable that we change - the slope. Today we will change only the variable -slope- to see if this made the plane fly farther.*

Have pupils adjust the slope of their flight line by lowering the far end 10 inches.

Show the transparency Master 2B from Lesson 2 as starting point of this experiment.

*We will use the number of winds shown here to send the plane halfway.*

**How many winds does it take to send the plane halfway?** (The answer is on the transparency.)

GUIDED PRACTICE

Materials Needed: See Lesson 1

Help set up the flight lines.

INDEPENDENT PRACTICE

The pupils will wind the plane * times to see if it flies farther than halfway.

CLOSURE

(All the variables were kept constant except for the variable slope.)

**Review the term controlled experiment. How did you control your experiment? Did the slope make a difference in how far the plane flew?** (Yes.)

**Did the dark room have an effect?** (We don't know!)

**How could we find out?** (Another controlled experiment could be done where the only variable that is changed is the room light.)

EVALUATION

Have pupils write the definition of a controlled experiment.

## Lesson 5 - What Do The Results Mean

NOTES

### GOAL/RATIONALE

The purpose of this lesson is to explore the concept of trends that can be observed in the results or data of an experiment. The concept of system as any set of parts put together to form a whole is developed in relationship to the concept of trend.

### ANTICIPATORY SET

*When we determined the number of winds needed to fly a particular distance, we didn't measure the exact distance in precise inches or feet. We used the terms 1/4 of the way, 3/4 of the way, and total way.*

**What did we find out with this experiment?** (With more winds, the plane flies farther.)

**When you wound the propeller 30 times did all of your planes fly the same exact distance?** (No.)

### OBJECTIVES

At the end of this lesson, the pupils will be able to:

1. Define the meaning of trend as it applies to the results of an experiment.
2. Define a system.
3. List the variables within a system that may or may not affect the experiment's results/data.
4. List some trend(s) of the experiment within this unit.

### DIRECT INSTRUCTION

*Even though the planes did not fly the exact same distance - only approximate distances - a general result or tendency developed, i.e. with more winds the plane flies farther. We call this general result or tendency a "trend."*

**Show transparency chart from Closure on Lesson 2 to visually reinforce the idea of trend.**

*There is a reason why we need sometimes to look for trends in our results instead of looking at exact/precise results. Sometimes there are variables that are not readily visible and those variables exist in a system.*

Write this definition on the board.

A **system** is any set of parts put together to form a whole. Your plane is a system made of parts.

**What are the parts of the plane system?** (Propeller, popsicle sticks, rubberband, straws, pins, line, etc.)

*Whenever you experiment with a complex system, you rarely get the same exact data as someone else. Consequently, you need to look for the trends in the data when working with a system.*

**Even though each group used ____ winds, why was the distance the planes traveled different?** (Variables within the system.)

**What are some of the variables within the plane system which may affect its performance?** (Parts fit differently, parts made differently, different amount of drag on the line, size of the rubberband, wear on the parts, propeller differences.)

List the pupils' ideas on the board or a chart for use in Guided and Independent Practice.

*Today when you fly your planes, be aware of these variables within the system which could affect the flight. Choose one of the variables of the system and try to control it to change the results.*

GUIDED/INDEPENDENT PRACTICE

*Set up your flight lines and try changing the variables within the system. Remember to change only one variable at a time to run a controlled experiment.*

CLOSURE

Discuss the pupils experiments and the results.

**With what variables of the plane system did you work?**

Review the terms variables, trends, and system.

END

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